DOCUMENT RESUME

ED 244 841 SE 044 566

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TITLE Learning about Learning: Classification Abilities. A Personal Workshop. Revised and Expanded Edition.
INSTITUTION California Univ., Berkeley. Dept. of Education.
PUB DATE 81
NOTE 110p.; For related documents, see SE 044 567-568.
AVAILABLE FROM Education Business Office, Attention: Publications, 1615 Tolman Hall, University of California, Berkeley, CA 94720 ($4.50, $4.00 for orders of 20 or more).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Classification; Cognitive Ability; *Cognitive Development; *Cognitive Measurement; *Diagnostic Teaching; Educational Diagnosis; Elementary Education; *Elementary School Science; Independent Study; Instructional Design; Science Education; *Science Instruction; Teacher Workshops

ABSTRACT

This book on classification abilities is part of a series designed to assist beginning and experienced teachers in becoming regular evaluators of their own instruction. The book consists of two sections. The first section provides information on: resemblance and consistent/exhaustive sorting; multiple membership and inclusive classifying; and horizontal and hierarchical reclassifying. The second and far longer section consists of 12 self-directed and self-instructive workshops. The goals of these workshops are to: (1) use a clinical method to administer, at any grade level, diagnostic tasks to ascertain classification abilities; (2) identify the developmental level of each student in terms of classification abilities; and (3) select, from resources available, subject matter (content and manipulative materials) appropriate to the identified levels of development in students' classification abilities. Except for the first workshop, the order in which workshops are completed or the number completed are at the discretion of the teacher. A short review of some research on classification abilities, a bibliography, and a sample record form are included. (JN)

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Educational Research and Applications Program
Department of Education
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Learning about learning:

Classification abilities

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LEARNING ABOUT...SERIES

Series developed by

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94720

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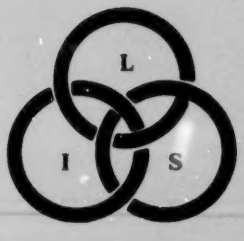

The mission of the Educational Research and Applications Program (ERA) is to explore the components which contribute to learning at all levels—early childhood to adult. There are three components to the exploration: The **Learner** (L), **Instruction** (I), and **Subject Areas** (S). Research and application in these interrelated areas can promote, for the teacher, a comprehensive approach to daily classroom situations and educational problems. The interwoven rings that comprise the logo for the program link the relationships of the components in such a way that if any one ring is broken, the entire relationship falls apart.

learning about learning:

classification abilities

A PERSONAL WORKSHOP

by

Lawrence F. Lowery

This personal workshop focuses upon the identification of a set of abilities related to learning. The set, described as classification abilities, is not independent of but is distinct from other sets of abilities described in other books in the "*Learning About ... Series.*" Although you will learn many ideas and develop various skills from experiencing this workshop, three major goals are identified below.

As a result of this
workshop, you will be able to:

1. use a clinical method to administer, at any grade level, diagnostic tasks to ascertain classification abilities.
2. identify the developmental level of each student in your class in terms of classification abilities.
3. select, from resources available, subject matter (content and manipulative materials) appropriate to identified levels of development in your students' classification abilities.

Hopefully you will become able to determine levels of development by observing students during their normal activities without relying upon the administration of the tasks.

This workshop is self-directed and self-instructive. It utilizes written materials, manipulative materials, audio or videotapes, and students in your classroom. It suggests ideas for teaching experiences, record-keeping systems, and discussions with colleagues.

The value of this and other books in the series depends upon the use of the presented ideas in instructional situations.

This book on Classification Abilities, developed by the Educational Research and Applications Program, is one of several under the general heading "*Learning About ... Series.*" The major objective of this series is to assist beginning and experienced teachers in becoming regular evaluators of their own instruction. Users of this series are taught to use materials and techniques that help assess stages of intellectual development in students, to identify and prescribe learning activities commensurate with their students' intellectual development, and to use techniques for assessing their interactions with students.

Many individuals contributed to the content and the field testing of this book. Others checked for detail and accuracy. Without their assitance and expertise, this book could not have been developed.

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Table of Contents

Introduction i

Classification Tasks

- Resemblance Sorting 1
- Consistent/Exhaustive Sorting 4
- Multiple Membership Classifying 6
- Inclusive Classifying 8
- Horizontal Reclassifying 11
- Hierarchical Reclassifying 13

Self-Workshops

- A. Assessing the ability to administer classification tasks 15
- B. Administering classification tasks to students 18
- C. Identifying cognitive operations related to classification abilities 20
- D. Identifying levels of classification abilities 23
- E. Observing the administration of classification tasks 27
- F. Relating games to levels of development 28
- G. Creating classification experiences 30
- H. Matching experiences to levels of development 32
- I. Identifying classification abilities related to mathematics 35
- J. Introducing the horizontal instruction model: resemblance sorting level 47
- K. Introducing the horizontal instruction model: multiple membership classifying level 58
- L. Introducing the horizontal instruction model: hierarchical reclassifying level 66

Review of Research 75

Bibliography 81

Appendix 85

INTRODUCTION

Careful researchers as well as general observers have well substantiated the idea that the human learning process progresses along a continuum that gradually enables individuals to cope more effectively and flexibly with situations and events within their environments. Along this continuum there are levels or way stations in which particular sets of abilities and behaviors are dominant. The characteristics of the behaviors at these way stations are so well defined that each is referred to as a stage of development. The progression along this continuum and through the identified patterns of stages is an universal and invariant process that can be observed in natural, untutored settings. The patterns are the same for all individuals whether they are raised within a primitive culture or a culture of advanced technology.

The biological basis underlying the stages along the continuum is established by periodic increases in brain size (Epstein 1974), brain weight (Epstein 1974), cellular growth within the brain (Winick and Rosso 1969), electrical functioning within the brain (Monnier 1960), and head circumference (Eichorn and Bayley 1962). The psychological basis for the stages is established through evidence of the individual's capacity to deal with independent ideas and to relate the ideas in increasing combinations in two-year spurts from about age three through 17 (Pascual-Leone 1970, Case 1974) and the individual's tendency to give the same kinds of incorrect views of the world as other individuals within two- to three-year ranges and as they grow older replace each view by a more sophisticated view which, in turn, is replaced (Piaget 1969). Although different researchers have provided various descriptions of the stage phenomenon (Bruner 1964, Erikson 1950, Gagnē 1970, Vygotsky 1974) the person most noted for carefully describing the sequence in terms of periods and stages is Jean Piaget, the Swiss psychologist. His work set a descriptive foundation and vocabulary that enables educators and psychologists to identify, discuss, explore, and perhaps apply information about the stages.

It is not the purpose of this book to present the theoretical ideas of Piaget. These ideas are spread over more than 30 volumes and many articles. It is hoped that the reader will turn to some of the original works to better appreciate and evaluate the spirit of Piaget's enterprise, the nature of his evidence, and the validity of his conclusions (Piaget 1952, 1958).

The Concept of Stages

The term *stage* has been used in the literature without much consistency in definition. In this and other books in the *Learning About...Series*, the term is reserved for qualitatively defined strands of abilities developing through progressive interrelationships. One strand deals with classification abilities. Others deal with seriation abilities, conservation abilities, and propositional reasoning. Conceptual links along any one of these strands allow each stage to be described as a set of behaviors sharing some common feature. As such, a stage is a construct within a structurally defined system upon which there is a unification of a specific set of abilities.

Describing the sequential progression is not sufficient for a definition of stages. A definition must include the patterning of responses throughout the sequence. The findings of Shirley (1931) represent an invariant sequence — the behaviors characteristic of the development of locomotion in infancy. However, the components of the sequence are essentially a set of discrete points which bear no clear structural relationship from one to another. Sitting up, for example, does not necessarily have a relationship to holding a hand. Although the sequence is invariant, thus predictable, its components are not stages since there is no structural relationship between them. A definition must include the patterning of responses throughout the sequence.

Stages in this book involve sequentiality, a hierarchical integration of lower into higher levels, gradual consolidation in formation, and a structural whole character (unifying interrelated behaviors, concepts, or skills). The result is a broad structural network of interrelated abilities appearing, not all at once, but within a fairly narrowly delimited period.

> Although at any stage of development, nature is preparing us for the next stage, the beauty of the system is that we are conscious of none of this. Ideally, we must fully accept and exist within our developmental stage and respond fully to its content and possibilities. This means that every stage is complete and perfect within itself. The three-year-old is not an incomplete five-year-old; the child is not an incomplete adult. Never are we simply on our way; always we have arrived. Everything is preparatory to something else that is in formation.
>
> Pierce 1977

Stages in the Classification Abilities Strand

The process of classifying lies at the very heart of human learning and sets humans apart from most primates and other animals. Scientists use the process whenever they define scientific concepts or use taxonomies. Each of us uses it frequently, for every word we speak, hear, read, write, or think denotes a group or class of objects or ideas. In an attempt to understand our world, we have become proficient in this process, making it one of the most powerful tools we have for producing and arranging information about our world.

In its behavioral form, classifying is exemplified by the ways through which we make sense of our environment by realizing "what things go together." In its cognitive form, it is the ways through which we mentally structure the sensory input from our environment. Many psychologists believe that the behavioral and cognitive forms are tightly interwoven because organizational abilities, such as sorting and grouping, appear to be preliminary and necessary for effective conceptualization to take place.

It is known that in the early levels of development, children tend to be perceptually oriented and seem to be able to sort objects on the basis of certain characteristics, but not others. For example, in our culture the ability to sort objects on the basis of color is the earliest to appear, and by age seven, the ability to sort by shape is predominant (Goldman 1963). Sorting by such characteristics as pattern (design on an object) is next, and then size (Johnson 1969). The sorting of objects by the materials of which they are made or by other abstract characteristics, such as molecular structures, develops much later. It is also known that at early levels, children group objects on the basis of single characteristics. The ability to use two or more discrete characteristics simultaneously as a basis for classifying is a higher level process that most children are not able to perform until about the fourth grade (Sigel 1966). Thus the ability to group objects by single perceptual characteristics develops early, then becomes less important in the child's organizational repertoire; the ability to group by more than one characteristic simultaneously or to group by abstract characteristics that are relatively autonomous of personal experience, develops later. It should be noted, however, that although early abilities recede into the background, they never disappear completely. They become incorporated with more advanced levels and are not independent of those levels. Some become less useful to the individual as more effective forms of organizing take their places, but they are never lost, and an individual may return to basic organizational abilities in order to comprehend a "new" situation.

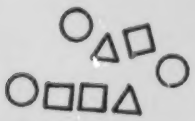
Some disagreement still exists about the placement of specific, identified abilities in the developmental sequence of the classification strand. The following list and the contents of this book represent only the identified abilities for which there is a broad agreement in findings among independent researchers as to the order of development (Piaget 1964, Kofsky 1966, Allen 1967, Hoople and Sipple 1974, Kroes 1974, Lowery 1976).

Inability to Classify

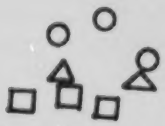
Accidental Representation

At this level the child arranges objects randomly and indicates no system that suggests an organized, rational plan although the final arrangement of objects might be a design or might accidently represent something such as a face or train.

Children at the accidental-representation level often create the following or similar arrangements and give the accompanying statements.

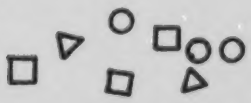


"This is a face."



"These are flowers I planted."

"These are pretty."



"These animals are playing."

Because an arrangement of objects by a child may suggest to an adult a classification on the basis of some attribute (e.g. two yellow objects might be placed next to each other), the child's verbal justifications must be checked to determine whether or not a classification ability was used (e.g. the two yellow objects may be placed together by accident).

Children at this level cannot arrange objects to represent something — if in the process of arranging the objects, the arrangement begins to look like something familiar to the child, the child may name or give explanation to the arrangement.

Pre-Classifying Abilities

Resemblance Sorting

This level of ability is characterized by the child's ability to group objects together on the basis of a common attribute such as color, shape, or size.

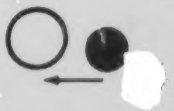
Without prior instruction, children at this level can be seen pairing objects in one-to-one correspondences because the objects resemble each other. The pairings appear as groups, piles, or chains of objects that allow the child to make basic comparisons of single attributes.

groups

piles

chain

If, on occasion, a student places more than one object into a group, the child's explanation is usually something like this: "I put this round one with this round one (a). Then I put this round one with this round one (to the disregard of the first object) (b)."

a 

b

Children at this level cannot put together all the objects that belong together, and although several different properties can be recognized, the child does not yet understand the simultaneity of the properties which comprise the object.

Card games that children enjoy and have success with at this level are Slap Jack and Concentration.

Consistent and Exhaustive Sorting

The sorting ability at this level is characterized by the child's grouping of *all* objects in a set on the basis of *one* common attribute.

Arrangements made by children will use up (exhaust) all the pieces to be grouped, and the child will give a rule that is logical (consistent) for all the groupings. For example, if the child puts all the blue objects together from an array of objects, the child will continue to sort the yellows, reds, and other colors into groups and say, "I've grouped all of these by their colors."

blue objects *red objects* *yellow objects*

All grouped on the basis of color

If earlier experiences have been rich, children at this level have acquired a broad repertoire of possible properties that make up objects. They can sort objects to the extent of that ability. Each sorting, however, is always on the basis of one property because children cannot yet combine more than one property. Evidence of this level appears in children's creative writing where each adjective used to describe something (property) is placed in its own sentence ("It is an *old* house. It is a *brown* house. It is an *empty* house."), or is chained together with connectors ("It is an old *and* brown *and* empty house").

Children in transition from the previous level to this level will often mix their logic for groupings.

blue objects *round objects* *red objects* *square object*

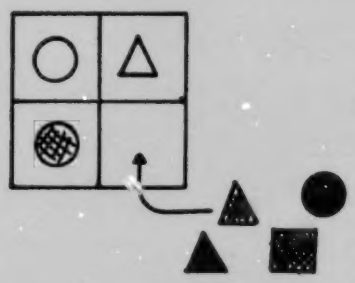
A card game that children readily learn and play successfully at this level is Fish — a game where sets are collected (all four Aces, all four 7s, etc.). A child at this level is often frustrated when playing a child at the previous level who only saves two cards in each set (the two black 9s, the two red 8s, etc.).

True Classifying Abilities

Multiple Membership Classifying

At this level the student can classify an object into *more than one* category *at the same time.*

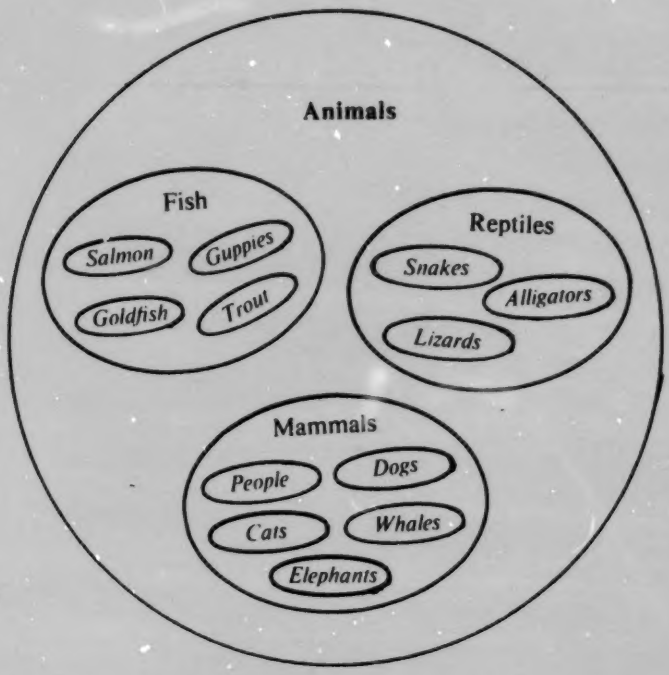
The student realizes the simultaneity of properties inherent in objects — that is, an object is both *brown* and *square* at the same time rather than being brown *and* being square. Arrangements of this level of thinking are complex.



A card game that students begin to play well at this level is Gin Rummy — a game in which sets (all the 3s, all the Jacks, etc.) or runs (three or more cards in sequence in a suit) can be saved simultaneously. A student at this level will consistently win over a student at the previous level who can save only one possibility at a time — either the run or the set, but not both.

Inclusive Classifying

The classifying ability of the student at this level is characterized by the inclusion of one class of objects within a superordinate class of objects. With the inclusion the student recognizes that the whole (larger class) is equal to the sum of its parts (the subclasses) and that there is a logical relationship between the larger and smaller classes. For example, the student realizes that all whales are mammals but that not all mammals are whales.



It is at this level that students understand that they live in a particular city *and* a particular state at the same time, *and* that one is superordinate to the other.

Flexibility in Classifying Abilities

Horizontal Reclassifying

An individual at this level can classify objects by one or more attributes, then reclassify them in numerous different ways, realizing that each way is possible at the same time and that the choice for an arrangement depends upon one's purpose. For example, if an individual is given a set of books with the identifying characteristics of size (number of pages), shape, color, and content, the individual realizes that the books can be organized on the basis of: size; shape; color; content; size and shape; size and color; size and content; shape and color; shape and content; color and content; size, shape, and color; size, shape, and content; shape, color, and content; size, shape, color, and content. Given the goal of locating information, the individual selects only the content as the organizing attribute because the other attributes are not useful to achieving the goal. Given a different goal, such as the determination of the ratio of books with fewer than 100 pages to those with more than 100 pages, the individual reclassifies the books for a different attribute to achieve that goal.

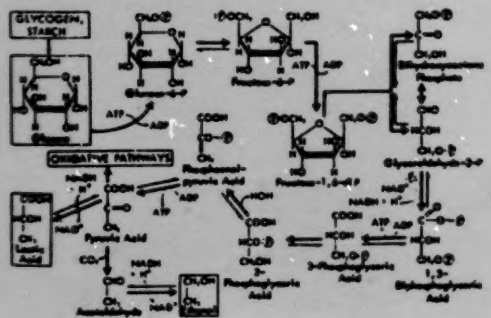
Hierarchical Reclassifying

This level is characterized by an individual's ability to classify and reclassify objects or ideas into hierarchies of increasingly related or inclusive classes.

At this level of ability, an individual can develop a taxonomy based upon a logical rationale concerning the relationships among the objects or ideas comprising the taxonomy while at the same time realizing that the arrangement is tentative, one of many possible arrangements that may be changed based upon fresh insights.

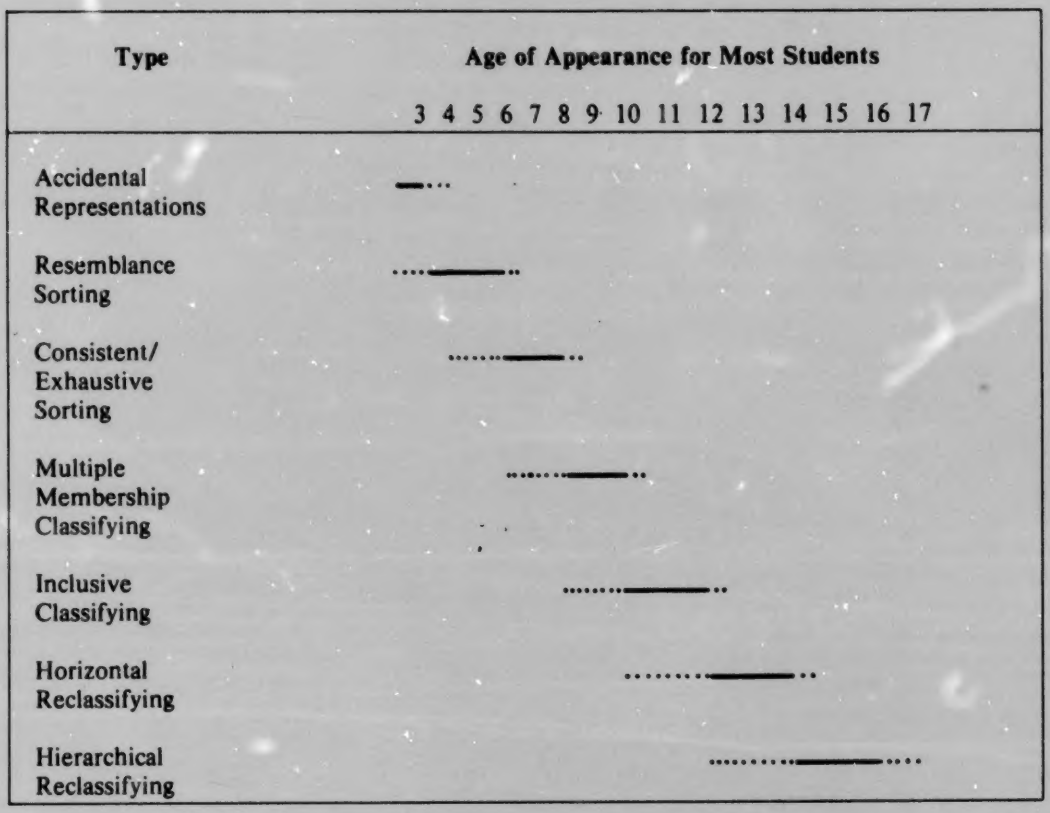
This level of classifying is complex and is expressed in many different ways. It requires flexibility in thinking.

DNA



EMBDEN-MEYERHOF PATHWAY

Types of Classification Abilities
Sequence of Appearances



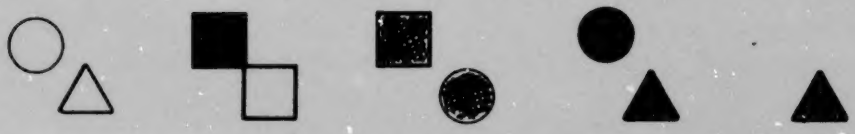
classification tasks

With a friend, take turns trying each of the classification ability tasks in this section.

At first, try to use the suggested dialogue that accompanies each task, then gradually incorporate your own style. Workshops A and B are designed to aid you in practice.

Note: It is a good procedure to be sure students can recognize the colors before beginning the tasks. The tasks have been designed so that the most common cases of colorblindness will not interfere with doing them.

Resemblance Sorting



Principle

Two objects can be grouped together because they are alike on the basis of one common attribute. For example, from a pile of leaves, two maple leaves can be put together because they are alike on the basis of shape. Most students attain this ability by age four-six (50% about age four, 90% about age six) (Kofsky 1966, Allen 1967).

Materials

1 small square (1" sides)* — blue.

2 medium squares (1½" sides) — 1 yellow, 1 red.

1 large square (2" sides) — red.

1 small circle (1" diameter) — orange.

7 medium circles (1½" diameter) — 2 blue, 2 orange, 2 yellow, 1 red.

3 large circles (2" diameter) — 1 blue, 1 red, 1 orange.

1 small equilateral triangle (¾" sides) — yellow.

2 medium equilateral triangles (2" sides) — 1 orange, 1 red.

1 large equilateral triangle (3¼" sides) — blue.

2 medium rectangles (2¼" x 1½" sides) — 1 yellow, 1 blue.

*NOTE: The sizes on this and subsequent tasks are suggestions. Such terms as "small," "medium," and "large" are the important factors for distinguishing size.

Task

The student (S) sits opposite or alongside the experimenter (E).

Procedure

E shows three sets of eight objects consecutively to S. Each of the sets, the shapes, colors, or sizes of objects are chosen so that S is forced to match on the basis of only one attribute.

Set 1

E places eight objects on the table in front of S:

2 squares (1 large, red; 1 small, blue).

6 circles (2 medium, blue; 2 medium, yellow; 2 medium, orange).

E directs the attention of S to the large red square. S is asked to select from the seven other objects, one which is "similar to" or "most like" it.

S is then asked to state the reason for that choice.

Set 2

E removes the previous set and places eight new objects on the table in front of S:

1 circle (small, orange).

2 squares (1 medium, yellow; 1 medium, red).

2 rectangles (1 medium, yellow; 1 medium, blue).

3 triangles (1 large, blue; 1 medium, red; 1 medium, orange).

E directs the attention of S to the small, orange circle. S is asked to select from the seven other objects, one which is "similar to" or "most like" it.

S is then asked to state the reason for that choice.

Set 3

E removes the previous set and places eight new objects on the table in front of S:

1 triangle (small, yellow).

7 circles (1 small, orange; 1 medium, orange; 1 medium, red; 1 medium, blue; 1 large, orange; 1 large, red; 1 large, blue).

E directs the attention of S to the small, yellow triangle. S is asked to select from the seven other objects, one which is "similar to" or "most like" it.

S is then asked to state the reason for that choice.

Analysis

For Set 1, S must disregard color and size, and match on the basis of *shape*.

For Set 2, S must disregard shape and size, and match on the basis of *color*.

For Set 3, shape and color must be neglected, and matching is done on the basis of *size*.

If matches are made correctly for at least two of the three sets, S is probably at or beyond the resemblance sorting level of development. If S has difficulty with one set, you might provide instructional experiences to enable S to become familiar with the attribute of the set.

Alternative Procedure

The objects in this task (squares, circles, triangles, rectangles) can be replaced by other objects (four different flowers, four different animals, etc.) or pictures of objects.

Consistent and Exhaustive Sorting

Principle

All objects in a set are grouped on the basis of one common attribute. For example, if some objects are grouped on the basis of shape (i.e., all circles are put together), then all objects are grouped on the basis of shape (i.e., all squares are put together, all triangles are put together, etc.). Most students attain this ability by age six-eight (50% about age six, 90% about age eight) (Kofsky 1966; Allen 1967).

Materials

1 small square (1" sides) — blue.

1 medium square (1½" sides) — yellow.

1 large square (2" sides) — red.

1 small circle (1" diameter) — yellow.

1 medium circle (1½" diameter) — red.

1 large circle (2" diameter) — blue.

1 small equilateral triangle (¾" sides) — red.

1 medium equilateral triangle (2" sides) — blue.

2 large equilateral triangles (3¼" sides) — 1 yellow, 1 orange.

1 medium rectangle (1¼" x 1¾" sides) — orange.

1 large rectangle (4" x 2" sides) — blue.

4 paper plates.

Task

The student (S) sits opposite or alongside the experimenter (E).

Procedure

E places the twelve objects on the table in front of S and determines S's vocabulary (i.e., S names shapes, sizes, colors).

E asks S to pick an object and set it on a paper plate (e.g., S selects the large yellow triangle).

E says, "Find all the other objects that are like the one on the plate, and place them on the plate also." NOTE: Three plates will be used if S selects size as the criterion. Four plates will be used if other attributes are selected.

When the plate has been filled with as many objects as S wishes (e.g., all the triangles, large objects, or yellows), it is removed or set aside.

The procedure is repeated until all the objects are sorted (e.g., S might next place the medium blue square on another plate). E then asks S to describe the common trait of the objects on each plate.

E empties the plates and places the first selected object (the large yellow triangle) on a plate. E says, "When you placed objects on this plate before, you placed them on the basis of (E gives attribute S selected — size, shape, or color). Show me another way that objects could be placed on this plate."

The procedure is repeated until all the objects are sorted. E then asks S to tell about each grouping.

Analysis

S must complete three or four complete sortings — either small, medium, or large; triangles, squares, circles, or rectangles; blues, reds, oranges, or yellows — and be consistent in the rationale used to indicate ability at or beyond the consistent and exhaustive sorting level of development. More specifically:

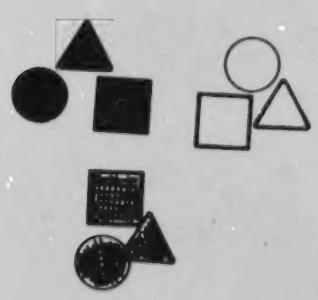
a. Each of the objects in the set of twelve must be assigned to a group.

b. Within each group, each object must possess the same attribute.

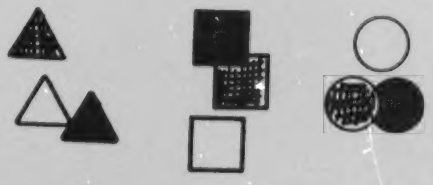
c. Every object in the original set possessing an attribute by which it could be sorted into another group is included in the appropriate group.

d. The same general type of attribute is the criterion for all sortings. If one group consists of similar shapes, so do the others.

The student who regroups the objects on the basis of another attribute indicates the flexible thinking typical of those who have attained this level of development. The individual who cannot sort using different attributes is very restricted in thinking and can consider only one rule, idea, or process at a time. When a single idea or procedure does not work, the individual tends to not know what to do.



"I can group them this way."



"I can group them this way, too."

Multiple Membership Classifying

Principle

An object can belong to more than one class or set at the same time. Most students attain this ability by age eight-ten. (50% about age eight, 90% about age 10) (Lovell 1962, Inhelder and Piaget 1964, Smedslund 1964, Bruner and Kenney 1966, Kofsky 1966, Allen 1967).

Materials

6 small equilateral triangles (¾" sides) — 4 red, 2 yellow.

4 large equilateral triangles (3¼" sides) — 2 red, 2 yellow.

1 small square (1" sides) — yellow.

1 large square (2" sides) — blue.

1 small circle (1" diameter) — red.

1 large circle (2" diameter) — orange.

4 loops of yarn (1' diameter) — 1 red, 1 yellow, 1 black, 1 white.

Task

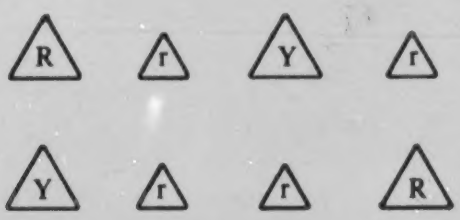
The student (S) sits opposite or alongside the experimenter (E).

E makes sure S understands the various shapes, sizes, and colors of the objects.

Procedure

Set 1

E places eight triangles in front of S in the following order:



E sets the red loop of yarn on the table and says, "This is a loop in which only red objects

can be placed. Do the small objects you see belong in this loop or not?"

After S responds, E asks for justification, "Why do you think so?"

E shows the black loop and says, "This loop is only for triangles. Do the yellows belong in this loop? Why do you think so?"

E asks, "Do the reds belong in the loop for triangles? Why do you think so?"

E shows the white loop and says, "This loop is only for small triangles. Do the yellows belong in it? Why do you think so?"

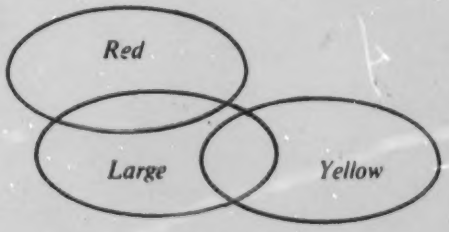
Set 2

E clears the table and places fourteen objects near S. E sets down the red loop of yarn and states, "I'm going to make up some rules for these loops and ask you to put objects within the loops according to the rules. For example, this loop will contain only red objects. Put objects in this loop according to the rule."

After S responds, E sets down the yellow loop and states, "Only yellow objects can go within this loop. Put objects into the loop according to the rule."

After S responds, E sets down the black loop so that it overlaps the first two as shown. E states, "Only large objects can go inside this loop. Please put objects inside all three loops according to the rules I've given you." (The rules can be repeated for S as necessary).

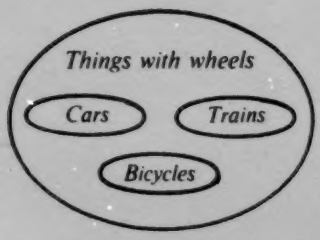
E can repeat the task with variations by simply changing the rules for the loops (e.g., large objects, small objects, and an overlapping loop for triangles).



Analysis

S's explanations must involve an accurate description of the attribute that the class in question and the objects in the loop share. If S correctly answers and explains three out of the four questions for Set 1, S is at the multiple membership classifying level of development. If S can place objects in the intersections of overlapping loops and explain their placement for Set 2, S can conceive of objects as simultaneously having more than one attribute.

Inclusive Classifying



Principle

If one class is included in another, then all the objects in the smaller class are but a part (some) of the larger. Conversely, some (a part) of the larger class is all of the smaller. For example, boys and girls are subclasses which comprise the total number of students (superordinate class) in a school. At this level of development students can understand relationships among two or more classes which share some or all attributes. In addition, they can compare extensions of the classes in terms of subordinate and superordinate relationships. Students attain this level by age 10 - 12 (50% about age 10, 90% about age 12) (Lovell 1962, Inhelder and Piaget 1964, Smedslund 1964, Vernon 1965, Kofsky 1966, Allen 1967).

Materials

10 equilateral triangles (2" sides) — 6 red, 4 yellow.

8 squares (1½" sides) — all yellow.

Task

The student (S) sits opposite or alongside the experimenter (E).

Procedure

E places all the objects in front of S and asks preparatory questions covering the identification of shapes and colors of the objects.

E then asks a series of questions, each followed with a request for S's justification for each response.

"Look at these objects. Are all the reds triangles? How do you know?"

"Are all the triangles red? Why do you think so?"

"Are all the squares yellow? Are all the yellows square? How do you know?"

"Are there more (or fewer) squares than there are yellows? How do you know?"

"Are there more (or fewer) triangles or yellows? How do you know?"

"If you stacked the objects into a pile, which of these ways would use more objects (or make the highest pile): 1) using the reds and yellows together; 2) using the squares and triangles together; or 3) using either combination? How do you know?"

Analysis

The materials used in this task were designed so that the objects can be subdivided in various ways. The yellows can be subdivided into squares and triangles with the squares being the larger of the two subclasses. Also, the set of triangles consists of red and yellow subclasses. There are more yellows than reds.

At the inclusive classifying level of ability, the student will correctly respond to the first six questions posed by the experimenter. A response to the final question should indicate that the student understands that there are as many objects in the superordinate class as there are in all of the subclasses (e.g., "There are as many reds and yellows together as squares and triangles so that either method would use the most blocks.").

Alternative Procedure 1

E sets out 15 brown wooden beads and five white wooden beads and a length of string for stringing them. E then asks a series of questions, each followed by a request for justification of each response.

"What are the beads made of?"(wood)

"Are they all made of wood? Are the brown ones made of wood? Are the white ones also made of wood?"

"How many wooden beads are there? How many brown ones? How many white ones?"

"Are there more brown beads or wooden beads?"

If S says there are more brown than wooden beads, E asks, "I know there are more brown than white, but are there more brown than wooden beads?"

If S persists, E might continue, "If I take all the white away, what will be left? What will be left if I take all the wooden beads away? Are there more wooden or brown beads? How do you know?"

E might also say, "If I used this string to make a necklace, which would make the longer necklace — one made of brown beads or one made of wooden beads?"

Alternative Procedure 2

One of Piaget's research designs utilizes 21 picture cards: three ducks, four birds that are not ducks, four animals that fly but are not birds, seven animals that do not fly, and three inanimate objects (Inhelder and Piaget, *The Early Growth of Logic.* New York, N.Y.: Norton, 1969). E asks S to arrange the picture cards in piles so that the animals resembling each other are in the same pile.

E asks, "Suppose these picture cards were put into this envelope labeled 'BIRDS'. Could these cards (ducks) and these (other birds) be put into the envelope and still keep the label?"

E then asks, "Suppose these picture cards were put into this envelope labeled 'ANIMALS'. Could these cards (birds) be put in with these (animals that do not fly) and still keep the label?"

Using the same envelope, E asks, "Could these (animals that do not fly) be put in with these (birds other than ducks) and still keep the label?"

Next, E asks: "If all the ducks were killed, would there be any birds left? If all the birds were killed, would there be any ducks left? If all the animals were killed, would there be any birds left?"

Horizontal Reclassifying

$$24 + 32 = (3 \times 8) + (4 \times 8)$$
$$= (3 + 4) \times 8$$
$$= 7 \times 8$$
$$= 56$$

Principle

An array of objects can be classified into groups using one set of attributes and can be reclassified on the basis of another set of attributes. For example, a set of rocks grouped on the basis of size and shape can be regrouped in a different way on the basis of color and texture. Most students attain this ability by age 12 - 14 (50% about age 12, 90% about age 14) (Kofsky 1966, Allen 1967).

Materials

1 (2" x 2" x 3/4") red, wooden block.

1 (1" diameter) red, rubber ball.

1 (1" diameter) red, round, wooden checker with a central hole.

1 (1/2" diameter) red, round, transparent, plastic checker.

1 (1" diameter) red, round, opaque, plastic checker with a ridged periphery on both surfaces.

1 (1/2" diameter) black, opaque, glass marble.

1 (1/2" diameter) opaque, glass marble, white with red swirls.

Task

The student (S) sits opposite or alongside the experimenter (E).

Procedure

S is presented with a set of seven objects. Each of the seven can be removed, and the remaining six objects can be classified on a single, common attribute that is not present in the removed object. The attribute on which the remaining six objects can be grouped varies, depending upon the object removed:

a. The wooden block is square, all the rest are round.

b. The rubber ball is soft, all the rest are hard.

c. The wooden checker has a hole in it, the rest are whole.

d. One checker is transparent, the rest are opaque.

e. The ridged checker is rough, the rest are smooth.

f. The black marble is black, the rest are red or partly red.

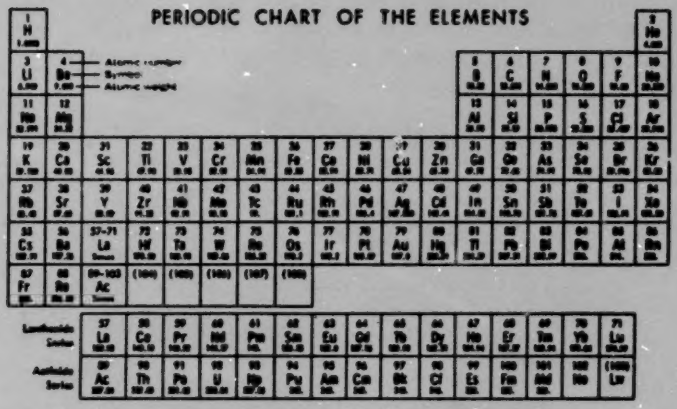
g. The white and red marble has two colors, the rest have one color.

E successively removes a single object from the set and asks S to supply an attribute common to the remaining objects. Negative statements of the following type are not acceptable: when the square is removed the remainder are described as "not square." (It is generally not effective to classify objects by non-characteristics). Two exceptions, however, can be permitted because S might not know the proper vocabulary terms. When the wooden checker with the hole is removed it is acceptable to describe the remaining objects as "not having holes," and when the transparent plastic disc is removed the remaining objects can be described as "those you can't see through."

Analysis

This task is designed to determine whether S can see differences and similarities among objects and can change the basis for grouping objects. A student at the horizontal reclassifying level should be able to supply an acceptable reason for grouping the objects in at least five of the seven groupings. NOTE: The student should reason that each of the six objects in each grouping possesses a common attribute and that this attribute is not present in the isolated (seventh) object. For example, it is not acceptable for a student to state that all the remaining objects are shiny, or that all are playthings, or that all make a noise when dropped.

Hierarchical Reclassifying



Principle

Objects or events may be arranged and rearranged into useful hierarchies of increasingly more inclusive classes. The fewer the attributes used to define the class, the more inclusive or general the class. For example, the class of red squares is included in the class of squares. Most students attain this ability by age 14 — 16 (50% about age 14) (Kofsky 1966, Allen 1967).

Materials

2 equilateral triangles (3¼" sides) — 1 green, 1 blue.

4 squares (2" sides) - red, green, orange, yellow.

3 rectangles (4" x 2") - red, orange, yellow.

5 circles (2" diameter) - red, green, blue, orange, yellow.

Task

The student (S) sits opposite or alongside the experimenter (E).

E places all the objects on the table in four groups: squares, circles, triangles, rectangles. E makes sure S can identify and name the shapes and colors.

Procedure

E begins, "Make 3 groups out of these 4 groups. If you move one object in a group, you must move all the objects in that group."

After S has regrouped the objects, E asks for justification: "Tell me why you decided to group them in that way."

After S has given his rationale, E says, "Combine these three groups you have made into two groups, and tell me your reason for the new grouping."

After S has regrouped the objects into two groups and states a reason, E says, "Now make one group and tell me your reason for it. Explain why the group is possible."

Analysis

S demonstrates competence in hierarchical reclassification by at least being able to combine four groups to form three and three to form two and by giving a satisfactory reason for each combination. For example, these materials might be grouped as "four-sided," "three-sided," and "one-sided" sets, then regrouped as "those with straight sides" and "those with curved sides," and finally as "all geometric forms."

The following pages contain
several self-directed workshops.

Except for the first workshop,
the order in which they are
done, the number that are done,
and the time it takes to do them
are up to you.

WORKSHOP **A**

assessing the ability to administer classification tasks

The purpose of this personal workshop is to guide you in practicing the tasks shown in the previous section. After finishing this workshop, you should be able to use an assessment method while administering the tasks.

Study the guidelines on the next page, then select a student in your classroom. Administer one or more classification tasks which you feel are appropriate to the student's stage of development.

Prepare an audio- or videotape of your session with the student.

At your leisure, review the recording and use the self-assessment sheet on page 17 to guide your analysis of your use of the method. Save the recording, then after further practice, compare a later recording.

Use the space below to jot down personal notes about your practice experiences.

SOME GUIDELINES FOR ADMINISTERING CLASSIFICATION TASKS

1. *Purpose.* The purpose for administering classification tasks is to determine the level of the student's classification ability.

2. *Situation.* The tasks presented in the previous section of this book are best administered on a one-to-one basis in a private place. After much practice, it is possible to carry out the procedure during natural classroom activities.

   Prior to the administration of the tasks, be sure the student understands the terms to be used or adjust your presentation to use the student's terms.

3. *The Assessment Method.* A good assessment of a student is not the result of following a prescribed procedure word for word; although as you begin word for word practice is important in developing a sense of good assessment technique. The heart of the assessment method rests in being attentive to what the student does, how the student explains what is done, and in making hypotheses about the student's behavior. Making educated guesses during the interview allows you to continually generate questions that further your understanding of the student's reasoning. Developing your skill in the assessment method takes time and practice.

   When you begin, present the materials to the student in a natural manner. For example, you might say, "Let's work with these for a while," or "I have some things I want you to do with these." Get directly into the interview rather than provide explanations about what you are going to do.

   As you administer the tasks, ask the student questions which refer to the objects you have presented. To obtain behavioral as well as verbal responses, have the student manipulate the objects and give a rationale for what is done.

   As you interview, be genuinely curious about and interested in the student's ideas. Do not be thinking about other things such as the papers that must be graded or the party you are going to. Not being "with" the student is quickly detected and will adversely affect the assessment. The basis for being "with" the student is to find out how he or she reasons.

   During the interview, ask questions which challenge the student's ideas in order to determine how firmly the student holds a belief or why the student believes as he or she does. Do this in a supportive, accepting, and non-judgmental way without leading the student to ideas you expect to find. *A typical mistake in beginning interviews is the attempt to get the best and most advanced response from the student.* Once a student gets the sense that you want something, the interview is affected. It is important to let the student lead while you follow, asking simple questions that reveal to you the student's thinking.

   Be flexible in interviewing. If the student does not understand what you ask, rephrase your question. If the student does not do what you ask, let the student fool around with the materials awhile. Some students need time to become comfortable with the materials. However, if the student drifts, remind him or her of what you want. This is important because a drifting student will do whatever he or she wants and you will learn little. To get the student back on the focus, you might say, "You can play with the blocks in any way you like after we've finished, but now I want you to..." With practice, and by being flexible, you will be able to incorporate any spontaneous activity into the interview by asking the appropriate questions to trigger the thinking you are assessing.

Although scripts indicating what to say are presented in this book, they serve only as a starting place. The questioning strategy to be used is not standardized. It should remain fluid and become part of your style. As you observe the student's manipulation of objects, listen to his or her responses and form guesses about the thinking, use your questions to test your hypotheses and, if necessary, to form other hypotheses about the student's ideas.

Be careful not to talk too much. This often confuses or leads the student into a particular line of thought. Give ample time for responses to your questions. Pause as long as necessary, and do not rush the student's thinking by asking a new question too soon.

The administration of a task should be pleasurable for you and the student. If you or the student are uncomfortable, it is best to discontinue the interview, and to try again at another time.

Self-Assessment: Using the Assessment Method	
Assessment	**Personal Notes**
a. What aspects of the interview indicated that I was non-judgmental and accepting of the student's ideas?	
b. What examples in the interview indicated that I avoided leading the student toward an idea I had?	
c. What evidence is there that I let the student's responses and actions guide the discussion?	
d. What evidence indicates that I approached the student where he/she was and responded to the situation independently of adult expectations of how he/she should act?	
e. What evidence indicates I formulated hypotheses concerning the student's strategies and tested the hypotheses through manipulations of the materials?	
f. In what ways did I check for justifications?	

WORKSHOP **B**

administering classification tasks to students

The purpose of this personal workshop is to guide you in administering classification tasks to students in your own classroom. After finishing this workshop, you should be able to administer the tasks and record the responses of the students.

Use the suggested record sheet on the next page (or a variation of it) to obtain data on several students in your classroom.

Videotape one of your sessions so that the experience can be added to your collection of videotapes.

Have a staff member discuss your tape with you, especially your use of the assessment method and workshop A.

Additional copies of the record sheet are found in the Appendix.

Record of Classification Tasks

Student_____ **Age**_____

Administered by_____

Task	Student's Responses	B	T	A	Administrator's Comments	Date
Resemblance Sorting						
Consistent & Exhaustive Sorting						
Multiple Membership Classifying						
Inclusive Classifying						
Horizontal Reclassifying						
Hierarchical Reclassifying						

NOTE: B = Below Level
T = Transition
A = At or Above Level

WORKSHOP **C**

identifying cognitive operations related to classification abilities

The purpose of this workshop is to give you practice in identifying cognitive operations in a different context. After this workshop, you should have a greater skill in transferring what you have learned to new situations.

Read the comic strips that follow. Each ends on a humorous point that requires attainment of a particular cognitive level for understanding. Try to explain each humorous point in terms of what you have learned in this program.

When finished, check your thinking with the general explanation given on the following page.

1 **FIGMENTS** —*By Dale Hale*

Copyright © Los Angeles Times. Reprinted with permission.

2. **PRICILLA'S POP** —*By Al Vermeer*

Courtesy of Newspaper Enterprises Association.

3. **YANKEE DOODLES** —*By Ben, Fred and Don*

Copyright © Los Angeles Times. Reprinted with permission.

4. **B.C.** —*By Johnny Hart*

By permission of John Hart and Field Enterprises, Inc.

5. **FUNKY WINKERBEAN** —*By Tom Batiuk*

I THOUGHT I'D BAKE SOMETHING FOR OUR NEXT 'RAP CELLAR' MEETING, JAN!
ARE YOU GOING TO MAKE IT FROM SCRATCH, MARCIA?
NO! I TRIED IT ONCE, BUT THE GRAVEL RUINED MY MIXER!
BATIUK

Courtesy of Field Newspaper Syndicate.

6. **WIZARD OF ID** —*By Parker and Hart*

By permission of John Hart and Field Enterprises, Inc.

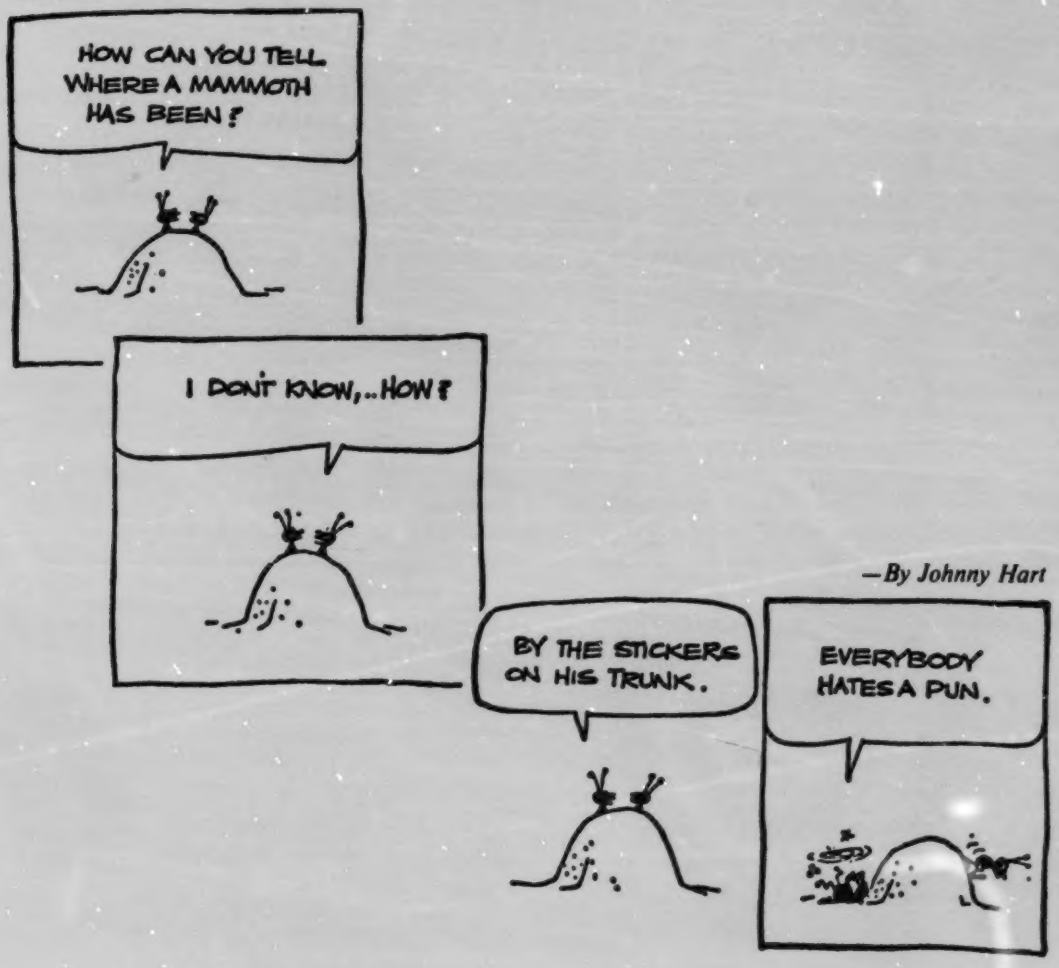
ANALYSIS OF COMIC STRIPS

To understand the humor in each of these comic strips, the reader must be at least at the multiple membership classifying level of cognitive development.

Multiple meanings are often used as a form of humor. A multiple meaning may range from a simple visual pun (Comic #1), verbal pun (#2) or combination (#3) to a very complicated relationship of several simultaneous thoughts (#6).

It should be clear that the words "bar examination" or "a good stiff belt" require the recognition of more than one meaning. All puns and much humor require the simultaneous recognition of multiple meanings.

B.C.



—By Johnny Hart

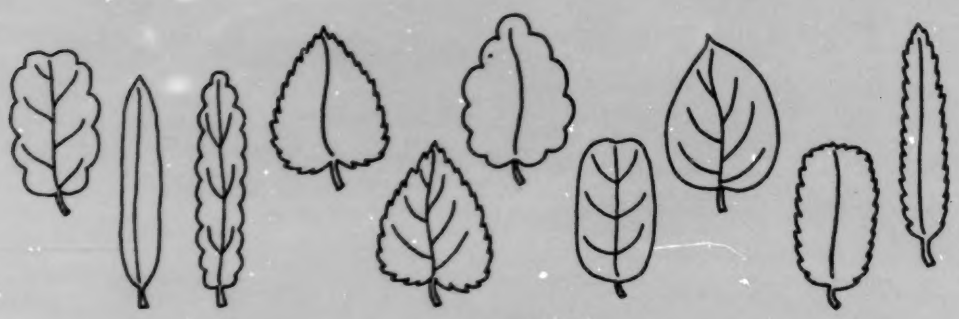
By permission of John Hart and Field Enterprises, Inc.

WORKSHOP **D**

identifying levels of classification abilities

The purpose of this workshop is to give you practice in identifying cognitive operations in a different context. After this workshop, you should have a greater skill in recognizing what you have learned in new situations.

The illustration below represents a set of objects that might be given to a student.

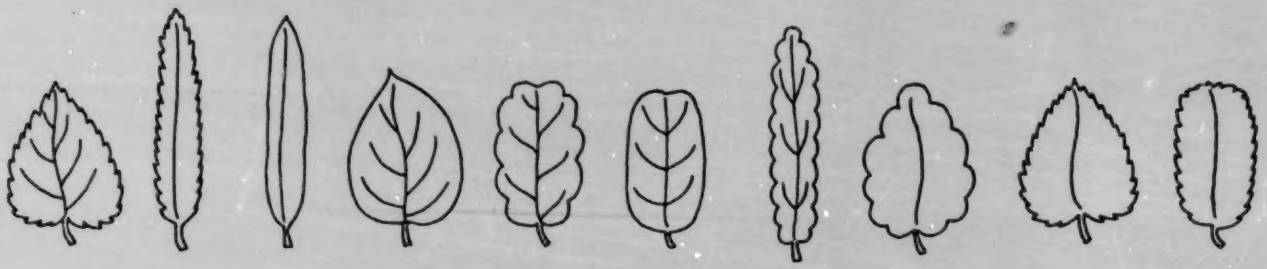


As the objects are picked up, moved, sorted, and rearranged, you might observe differences in performance. The differences are reflective of thinking strategies and may be highly individualized. The final arrangement that a student makes will not be representative of a "correct" or "incorrect" solution but will be an indication of the student's level of intellectual development.

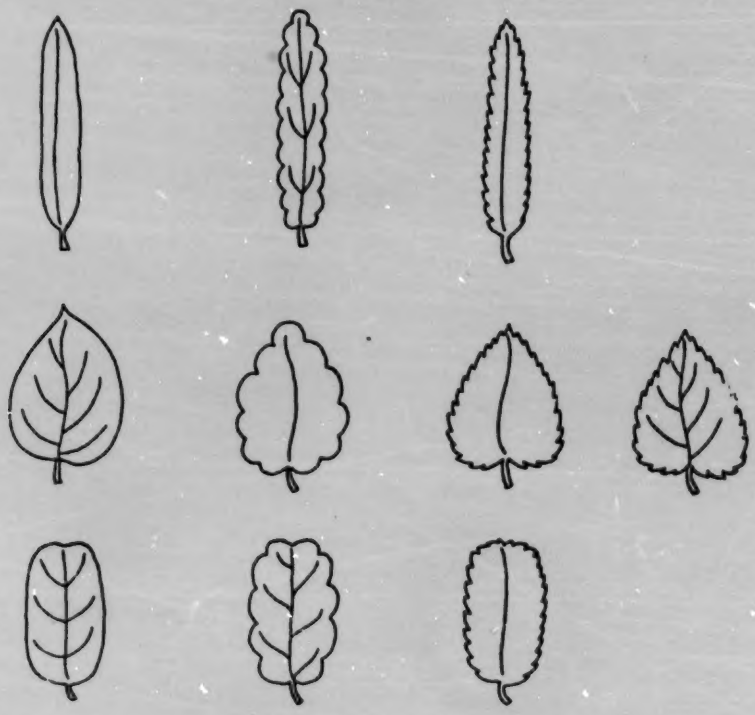
For each of the illustrations on the next two pages, try to identify the level at which the student performed. NOTE: In reality, a teacher should talk with the student about an arrangement, for the arrangement itself does not reveal all the thinking that might have taken place.

You may wish to check your identifications with those of other teachers, some of which follow the illustrations.

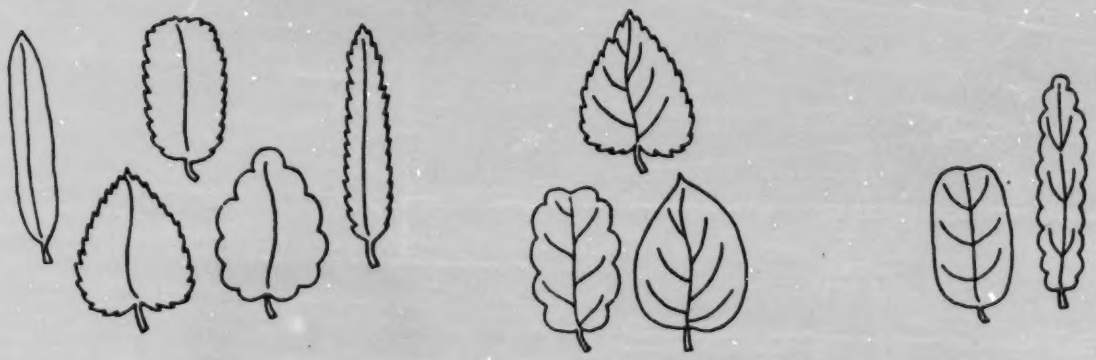
1. Level of classification ability:_____



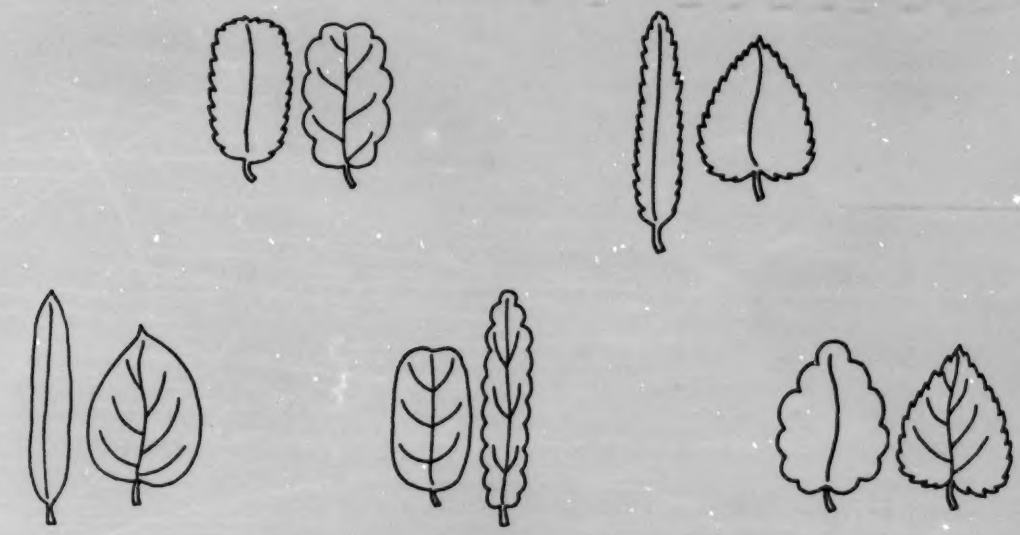
2. Level of classification ability:_____



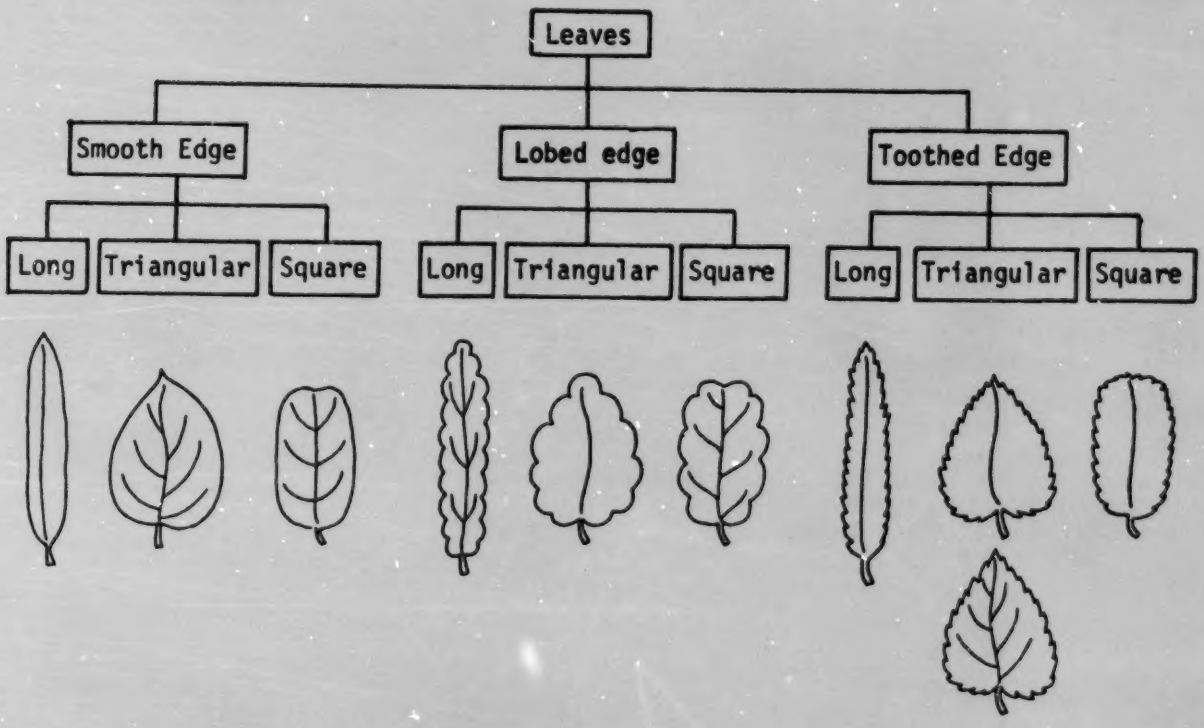
3. Level of classification ability:_____



4. Level of classification ability:_____



5. Level of classification ability:_____



Analysis of Leaf Classification

1. *Resemblance Sorting Level.* Note that the leaves are sorted in overlapping pairs (e.g., The first pair is sorted by serration; second pair by shape; third by serration; fourth by venation; etc.). The shifting of criteria is an indicator of a student being at the resemblance sorting level. Another indicator is that the materials are arranged in one-to-one relationships.
2. *Multiple Membership Classifying Level.* This arrangement indicates an integrated grid involving intersections of two or more properties for most of the leaves. For example, the leaf in the upper left corner fits into two sets simultaneously — the top row of leaves on the basis of shape and the left hand column on the basis of serration. The realization that an object possesses two or more properties *simultaneously* is an indicator of a student being at this level of development.
3. *Consistent and Exhaustive Sorting Level.* In this arrangement, all the leaves are sorted on the basis of one property — venation. Consistency in criterion and arrangement of the whole set are two indicators of this level of development.
4. *Resemblance Sorting Level.* The leaves are arranged in one-to-one relationships, each pairing involving only one property common to both leaves. Since the criterion varies among the different pairings, the student is not yet at the next level of development which involves consistency of criterion.
5. *Hierarchical Reclassifying Level.* The leaves have been classified into groups and sequentially subgrouped to produce a hierarchical arrangement in which each subgroup has membership in more inclusive superordinate groups. The ability of the student to rearrange the total set into a hierarchy involving other criteria would be an indicator of this level of development.

WORKSHOP **E**

observing the administration of classification tasks

The purpose of this workshop is to provide additional practice in assessing levels of development and in analyzing interviewing procedures. After finishing this workshop, you should be able to better identify levels of classifying abilities.

View the PDARC videotape* on Classification Abilities with several other teachers. The tape will show students at different levels of cognitive development responding to a classification task.

When you finish viewing the tape, discuss the following with your colleagues:

1. What behaviors indicated each student's developmental level?
2. What verbal responses and actions distinguished the different levels of development?
3. Use the sheet on page 17 to analyze the assessment method used by the interviewer. Did the interviewer lead the student into a particular line of thought? Did the interviewer rush the student's thinking?

* Videotape available from: PDARC, Graduate School of Education, University of California, Berkeley, CA 94720

WORKSHOP **F**

relating games

to levels of development

The purpose of this workshop is to give you further practice in identifying cognitive operations in a different context. After this workshop, you should be able to use your assessment skills more broadly.

The following represent a few card games which most students learn to play.*

In order to be played effectively, each game requires that the student has reached a particular level of development. In terms of classification abilities, try to identify the levels of development. Discuss your judgments with colleagues.

*Hoyle, *Official Rules of Card Games*. United States Playing Card Company, Cincinnati, Ohio.

Go Fish

(Fish, Go Fishing, Authors)

Number of Players—Two to five.
The Pack—52 cards.
The Draw—Any player deals one card face-up to each player, and low deals, the cards ranking from A (high) to a 2 (low).
The Shuffle and Cut—Dealer shuffles the cards and the player at his right cuts them.
The Deal—Cards are dealt one at a time to the left, beginning with the eldest hand. With two or three, each player receives seven cards; with four or five, each receives five. The remainder of the pack is placed face down on the table to form the *stock*.
The Play—Eldest hand begins by saying "(John), give me your kings," addressing by name any of the other players, and naming any rank provided he himself holds at least one card of that rank. The player addressed must hand over all of the cards asked for, but if he has none, he says, "Go fish!" and the asker draws the top card of the stock.

Level

When a player has had to fish, without making a catch, the turn to ask passes to his left.

The object in play is to form *books*. A book is any four-of-a-kind, as four kings. On getting the fourth card of a book, the player shows all four, places them on the table before himself, and plays again.

If the asker gets one or more cards of the named rank from the player addressed, he asks again. He may address the same or any other player and name the same or any other rank. So long as he is successful in getting cards, his turn continues. Also, if when told to fish he gets the fourth card of the book in the rank named, he shows the book and his turn continues. (*Variant.* Some like to play that the turn continues when the fisher gets the card named from the stock, even though it does not complete a book).

The game ends when the ownership of all thirteen books has been decided. If one player is left without cards, he may in turn draw from the stock and ask for cards of that rank, but if the stock is gone he is out of the play.

Concentration (Memory)

This is an excellent game for any number of players of any type—serious players, casual players, even people who have never played cards before.
Number of Players—Any number from two up.
The Pack—52 cards.
The Deal—Any player shuffles the pack and lays all the cards out face down, one at a time, so that no two cards touch or overlap at the corners. The entire surface of the table is usually necessary to make room for all the cards.
Object of the Game—To take in pairs of cards of the same denomination, as two sixes or two queens.

Level

The Play—The first player may be decided in any way. Each player in turn must turn up any two cards on the table, leaving the first face up until he has turned the second. If the two cards form a pair, he takes them and turns up two more cards. Whenever the two cards he turns up do not form a pair, he turns both cards face down again, leaving them in exactly the same position on the table that they were in when he first turned them. The turn to play then passes to the player on his left.
Scoring—There are alternative methods:

(a) The player who takes in the greatest number of pairs receives one counter, or chip, or point, from each other player in the game; if two players tie for the highest number of tricks, they split the winnings.

(b) Each player collects one counter from each other player for every pair he has taken in.

Old Maid

This game is a perennial favorite with children.
Number of players—Any number from two up, each playing for himself.
The Pack—51 cards (a 52-card pack with one of the four queens discarded).
The Deal—Any player shuffles the pack and deals them around, one at a time to each player, as far as they will go; they do not have to come out even.
Object of the Game—To form and discard pairs of cards, and not be left with the odd card at the end.

Level

The Play—Each player removes from his hand, in twos, all pairs of cards (with three sixes a player may remove only two of them). The dealer then offers his hand, spread out face down, to the player at his left, who draws one card from it. This player discards any pair which may have been formed by the card drawn, then offers his own hand to the player at his left. Play proceeds in this way until all cards have been paired but one—the odd queen, which cannot be paired—and the player holding that card is the Old Maid.
Irregularities—If any player discards two cards which are not a pair, causing three unpaired cards instead of one to remain at the end, the player who committed the irregularity is the Old Maid.

Gin Rummy

This has become the most popular two-handed variant of the Rummy family. It is the favorite among all games with the motion picture, radio, and theatrical world.
Number of Players—Two. Three may participate in the same game, usually with one sitting out while the other two play. Four or more, in pairs up to almost any number, may play a partnership game, but this is done by playing separate two-hand games and combining scores.
The Pack—52 cards. Two packs should be used, so that while one player deals the other shuffles for the next deal.
Rank of Cards—K (high), Q, J, 10, 9, 8, 7, 6, 5, 4, 3, 2, A.
Value of Cards—Face cards, 10 each; ace, 1; other cards their pip value.
The Shuffle and Cut—One pack is shuffled and spread, and each player draws a card; if he draws one of the four cards at either end, he must draw again. If the cards drawn are otherwise of the same rank, the suits rank: spades (high), hearts, diamonds, clubs. The player drawing the high card has choice of cards and seats, and whether or not he will deal first. Either player may shuffle, the dealer having the right to shuffle last. Non-dealer must cut the pack.

Level

The Deal—Dealer gives the cards, one at a time, face down, alternately to his opponent and to himself until each has ten cards; the next card, called the *upcard*, is placed face-up in the center of the table, and the remaining cards, called the *stock*, are placed face down beside it.
Object of Play—To form *matched sets*, consisting of three or four of a kind, or of sequences of three or more cards of consecutive rank in the same suit.
The Play—Non-dealer plays first, and the turn to play alternates thereafter. In each turn, a player must draw either the upcard (top card of the discard pile) or the top card of the stock, and then must discard one card (which may not be an upcard he has drawn in the same turn) face-up on the discard pile.

On the first play, if non-dealer does not wish to take the upcard he must so announce and dealer may have the first turn by drawing the upcard; if dealer does not wish the upcard, non-dealer draws the top card of the stock and play proceeds.

WORKSHOP **G**

creating classification experiences

The purpose of this workshop is to give you a chance to create subject area experiences related to levels of development.

For each of the appropriate levels of classification abilities, create an experience for the students you are now teaching. (This means that you might not create experiences for some of the abilities listed). You might try to do this for particular subject areas such as mathematics, science, or social studies.

In the following listing are two samples: a resemblance sorting experience designed for students in a preschool or kindergarten class; a horizontal reclassifying experience in mathematics for students in junior high school.

Resemblance Sorting (Kindergarten)

Purpose: At the end of this experience, students will be able to: 1) identify and name the primary and secondary colors, 2) match two objects on the basis of color.

Procedure: Provide students with an assortment of paper cups of the same size and shape, but of different colors (red, blue, yellow, green, orange, purple). Introduce another cup that matches by color one of those in the assortment. Ask a student to find a cup that matches it, then let him explain his reasoning for the selection.

Consistent and Exhaustive Sorting

Purpose:

Procedure:

Multiple Membership Classifying

Purpose:

Procedure:

Inclusive Classifying

Purpose:

Procedure:

Horizontal Reclassifying (Junior High)

Purpose: To introduce the Distributive Property in mathematics

Procedure: Show on a chalkboard, the following idea — To name a sum where the addends have a *common factor*, one may first multiply the *common factor* and then add

$$(3x4) + (7x4) = 12 + 28 = 40$$

or one may add and then multiply by the *common factor*

$$(3x4) + (7x4) = (3+7) \times 4 = 10 \times 4 = 40$$

Give students the following exercises to work.

Name the sums and products.

1. (3 X 6) + (7 X 6) =
2. (3 X 10) + (7 X 10) =
3. (3 X ¼) + (7 X ¼) =
4. (3 + 7) X 6 =
5. (3 + 7) X 10 =
6. (3 + 7) X ¼ =

Hierarchical Reclassifying

Purpose

Procedure:

WORKSHOP **H**

matching experiences

to levels of development

The purpose of this workshop is to give you the opportunity to assess curriculum experiences in terms of classification abilities. It is hoped that you will become skilled in matching experiences to levels of cognitive ability.

The following experiences involve sorting, grouping, or classifying. Read each experience and try to identify the minimal developmental level of a student who is able to do each experience successfully.

You might wish to compare your identifications with those made by other teachers. Their explanations are given on the following page.

Experience 1

Have a student find the two identical (or most alike) objects which are mixed within a set of different objects. After matching objects, ask the student to state a reason for the selection.

Experience 2

Distribute the following materials: banana, orange, orange marshmallow, orange jawbreaker, orange button, orange lifesaver, orange gum. Have a student remove one item from the set and tell what the remaining items have in common. Do this for each of the items in the set.

Experience 3

Prepare a set of picture cards which show pictures of objects whose initial consonant sound is "m." Also include pictures whose initial consonant sound is other than "m." Add a few more pictures which illustrate words that rhyme with some of the words in the "m" group as well as with some of the assorted sound group. Show the pictures to a student and ask him to find all the pictures which belong in the "m" group. (Don't say the letter name, just make the sound). Next, have the student find all the pairs of rhyming words and group them together.

Experience 4

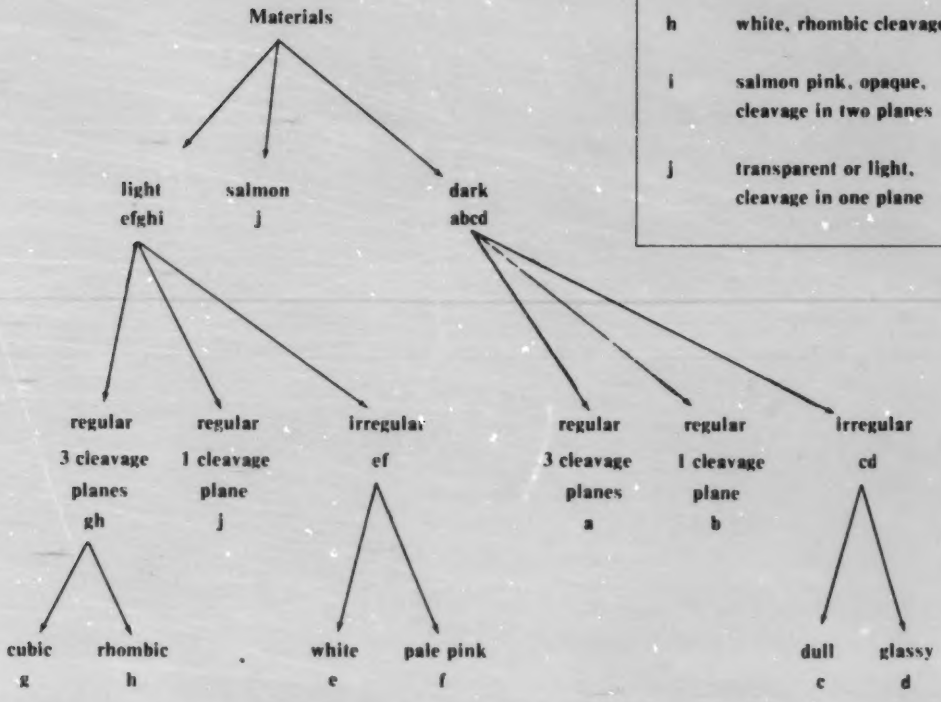
Prepare a box of beads of various sizes, shapes, colors, and materials. Be sure that for every bead there is a matching bead. To begin, select one bead from the box and thread it on a string. Have a student find a matching bead in the box and add it to the string. Let the student tell why he selected the bead, then ask him to place a bead of his own choice on the string. When this is done, another student can search for the matching bead. Students can continue taking turns doing this activity.

Experience 5

Provide the students with the 10 materials listed in the chart. Let the students determine the properties of the materials using hand lenses and by testing. Next, ask them to develop a classification system based upon their findings (one possible system is shown below). When finished, provide another material that was not part of the original set. Ask students to add the new material to their classification system so that it is logically included.*

Chart of Materials

Code Letter	Properties	Name
a	metallic luster, gray, cubic cleavage	galena
b	black, cleavage in one plane (flakes)	biotite
c	brittle, black, irregular fracture	anthracite coal
d	gray or black, transparent at edges, glassy, irregular fracture	obsidian
e	white, glassy, irregular fracture	milky quartz
f	pale pink, glassy, irregular fracture	pink quartz
g	white, cubic cleavage	halite
h	white, rhombic cleavage	calcite
i	salmon pink, opaque, cleavage in two planes	orthoclase
j	transparent or light, cleavage in one plane	muscovite



* This experience was adapted from the Princeton Project "Time, Space, and Matter." McGraw-Hill Publishing Company, 1969.

Analysis of Classroom Experiences

1. *Resemblance Sorting Level.* In this experience, the student is asked to put two objects together because they are alike in some way. Experiences requiring one-to-one relationships involve students at the resemblance sorting level of classification abilities.

2. *Horizontal Reclassifying Level.* This experience asks the student to classify, then reclassify the same group of objects in numerous ways without constructing subgroups. Note that all the objects become involved in complex multiple membership classifying relationships.

3. *Multiple Membership Classifying Level.* This language arts experience requires the student to concentrate simultaneously upon two or more characteristics related to symbols and sounds. Although it is more complex than just multiple membership classifying thought, this level of development is a minimal requirement for doing the experience successfully.

4. *Resemblance Sorting Level.* This is a simple copying or matching experience. Students are given a clue object and are asked to find one other to match it.

5. *Hierarchical Reclassifying Level.* This science experience has the student arrange (and perhaps rearrange) a set of objects into a useful hierarchy (useful in the sense that unclassified objects can be added to the structure) involving increasingly more inclusive classes.

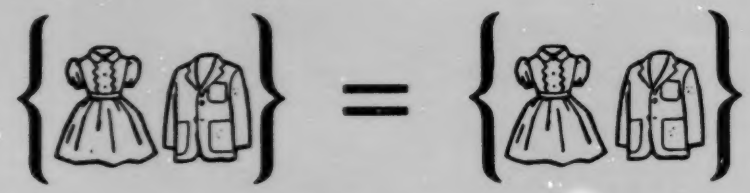
WORKSHOP **I**

identifying classification abilities related to mathematics

The purpose of this workshop is to give you practice in identifying cognitive operations asked of students by various mathematics programs. After this workshop, you should be able to recognize what classification abilities are asked of students by such math programs and to sequence the tasks according to stages of development.

On the next ten pages are samples from various mathematics programs. Identify the level of classification ability required for a student to do each sample successfully, then number the samples to represent a developmental sequence.

SAMPLE I[1]
Level of ability_____
Number in sequence_____



Sets are equal when they have the same things in them.

☒ the equal sets.

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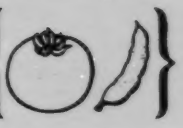
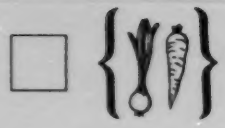
☐ 

☐ 

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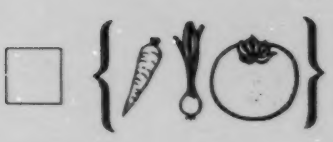
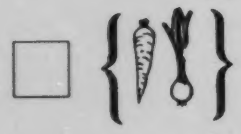
☐ 

☐ 

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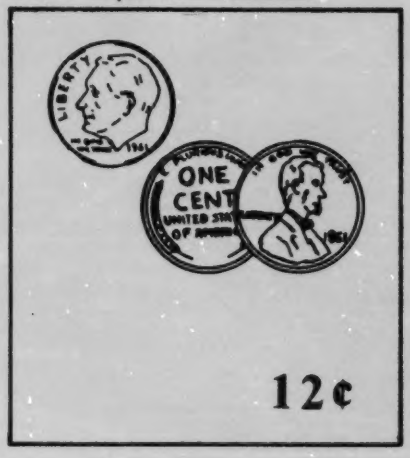
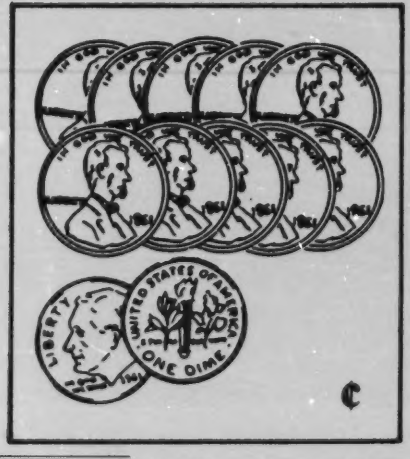
1. Suppes, Patrick and Joanne Suppes. *Sets and Numbers 2.* California State Series, Sacramento, CA 1970.

SAMPLE II[2]
Level of ability_____
Number in sequence_____

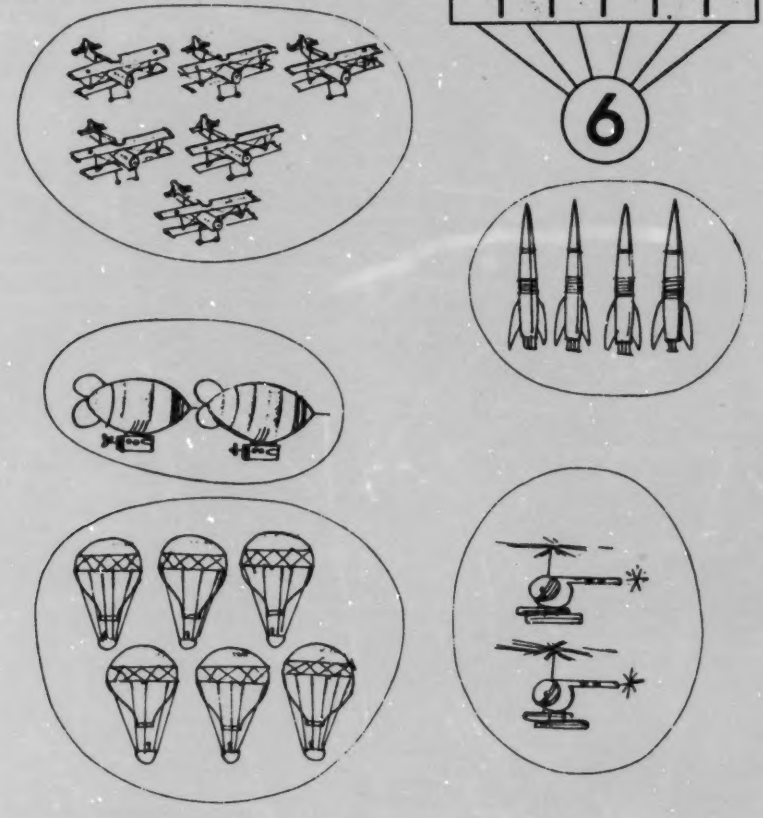




2. Wirtz, Robert et al. *Math Workshop Level A.* California State Series, Sacramento, 1964.

SAMPLE III[3]
Level of ability_____
Number in sequence_____

Draw a line under each set of **6**.



Sets of **6**

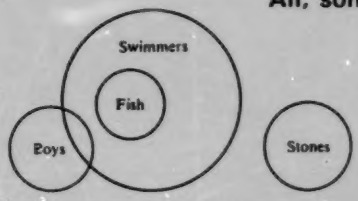
3. Calif. State Series. *Modern School Mathematics, I.* Sacramento, 1970

SAMPLE IV[4]
Level of ability_____
Number in sequence_____

All, some, none

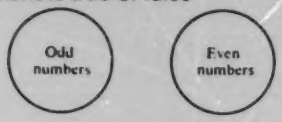
This diagram shows:

All fish swim.
Some boys swim.
Some boys do not swim.
No stones swim.

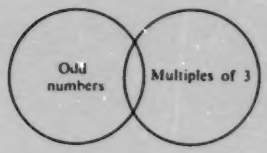


EXERCISES

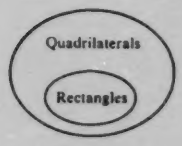
Study the diagrams. Write *T* or *F* to show whether each statement is *true* or *false*



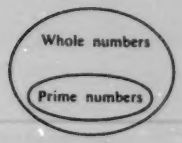
1. No even numbers are odd.
2. No odd numbers are even.
3. Some odd numbers are even.



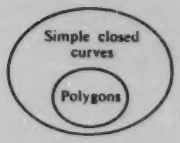
4. Some multiples of 3 are odd numbers.
5. Some odd numbers are multiples of 3.
6. All odd numbers are multiples of 3.



7. All rectangles are quadrilaterals.
8. Some rectangles are not quadrilaterals.



9. All prime numbers are whole numbers.
10. No prime numbers are whole numbers.

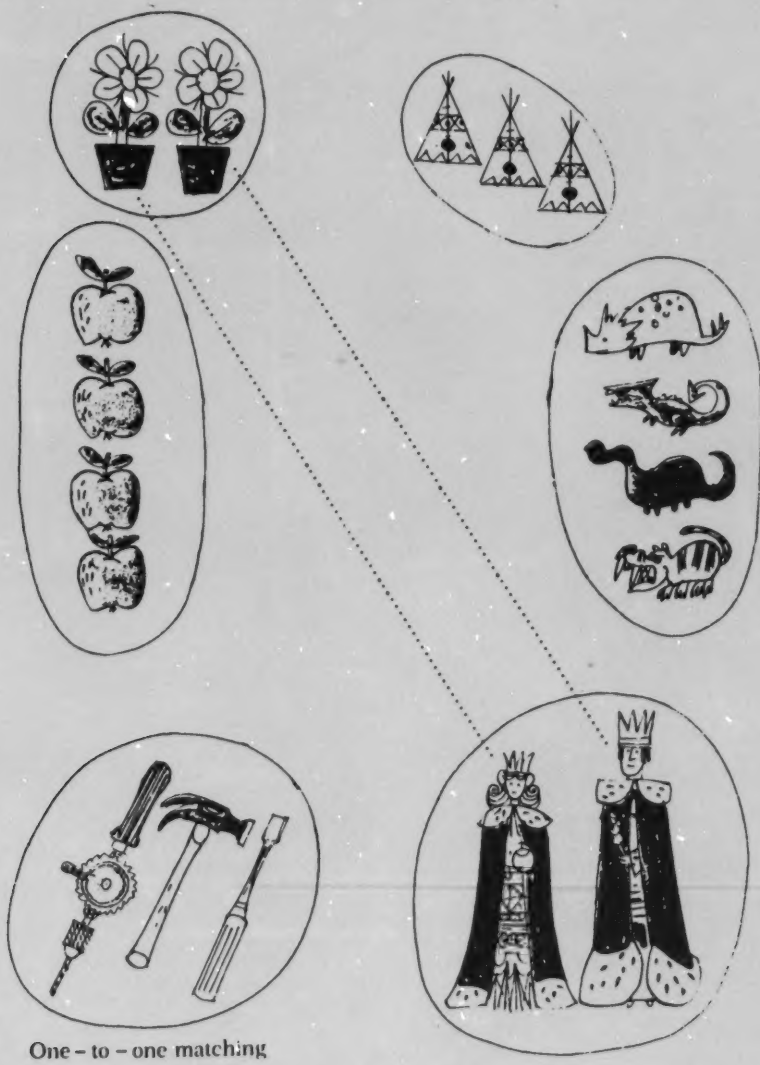


11. All polygons are simple closed curves.
12. Some polygons are not simple closed curves.

4. Calif. State Series. *Modern School Mathematics, 4.* Sacramento, 1970.

SAMPLE V[5]
Level of ability_____
Number in sequence_____

Draw lines to match the objects in the sets.



One – to – one matching

5. Calif. State Series. *Modern School Mathematics, I.* Sacramento, 1970.

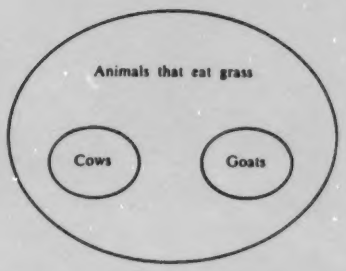
SAMPLE VI[6]
Level of ability_____
Number in sequence_____

If - then

The diagram shows:

All cows and all goats eat grass.

Animals that eat grass may be cows or goats or some other kind of animal.



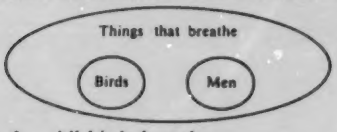
We can also say:

If an animal is a cow or a goat,
then it eats grass.

If an animal eats grass,
then it may be a cow or a goat
or it may be some other kind of animal.

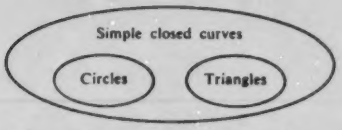
EXERCISES

Study the diagrams. Write *T* or *F* to show whether each statement is *true* or *false*.

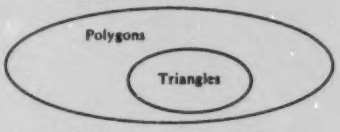


1. All birds breathe.
2. If it is a bird, then it breathes.
3. If it breathes, then it must be a bird or a man.
4. If it breathes, then it must be a bird.

8. All cars have wheels.
9. If it is a car, then it has wheels.
10. If it is a bicycle, then it has wheels.
11. If it has wheels, then it must be a car.



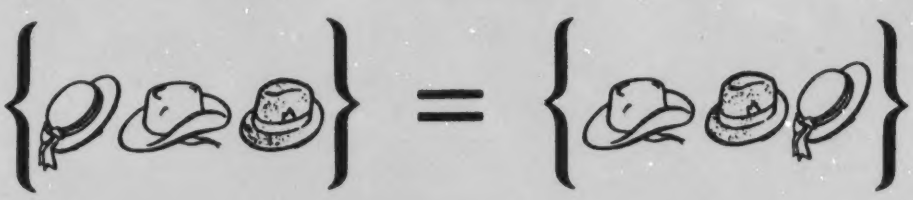
5. If it is a circle, then it is a simple closed curve.
6. If it is a simple closed curve, then it is a circle.
7. If it is a triangle, then it is a simple closed curve.



12. If it is a triangle, then it is a polygon.
13. If it is a polygon, then it is a triangle.
14. If it is not a polygon, then it is not a triangle.

6. Calif. State Series. *Modern School Mathematics, 4.* Sacramento, 1970.

SAMPLE VII[7]
Level of ability_____
Number in sequence_____



Sets are equal when they have the same things in them.

☒ the equal sets.

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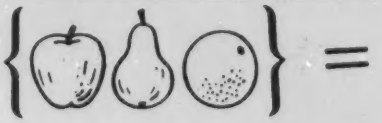

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7. Suppes, op. cit.

SAMPLE VIII[8]
Level of ability_____
Number in Sequence_____

Properties of the number operations

distributive property

To name a sum where the addends have a *common factor*, we may first multiply by the *common factor* and then add

$$(3 \times 4) + (7 \times 4) = 12 + 28 = 40$$

or we may add and then multiply by the *common factor*

$$(3 \times 4) + (7 \times 4) = (3 + 7) \times 4 = 10 \times 4 = 40$$

EXERCISES

Name the sums and products.

1. $(3 \times 6) + (7 \times 6) = a$
2. $(3 \times 10) + (7 \times 10) = c$
3. $\left(3 \times \frac{1}{4}\right) + \left(7 \times \frac{1}{4}\right) = e$
4. $(3 + 7) \times 6 = b$
5. $(3 + 7) \times 10 = d$
6. $(3 + 7) \times \frac{1}{4} = f$

Solve the equations.

7. $3 \times 20 = a$
   $3 \times 4 = r$
   $3 \times 24 = c$

8. $20 \times 7 = m$
   $5 \times 7 = n$
   $25 \times 7 = z$

9. $16 \times 20 = u$
   $16 \times 4 = v$
   $16 \times 24 = i$

10. $8 \times 13 = s$
    $9 \times 13 = n$
    $17 \times 13 = u$

11. $3 \times 400 = e$
    $3 \times 8 = a$
    $3 \times 408 = r$

12. $12 \times 10 = v$
    $13 \times 10 = w$
    $25 \times 10 = x$

13. $\frac{1}{2} \times 20 = x$
    $\frac{1}{2} \times 4 = e$
    $\frac{1}{2} \times 24 = n$

14. $8 \times \frac{1}{2} = s$
    $16 \times \frac{1}{2} = u$
    $24 \times \frac{1}{2} = r$

The distributive property is used in this example.

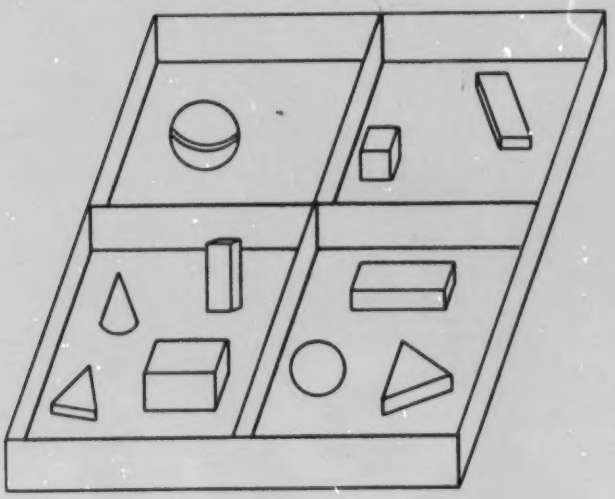
$$\begin{array}{r} 37 = \quad 30 + 7 \\ \times\ 8 \qquad \times\ 8 \\ \hline 240 + 56 = 296 \end{array}$$

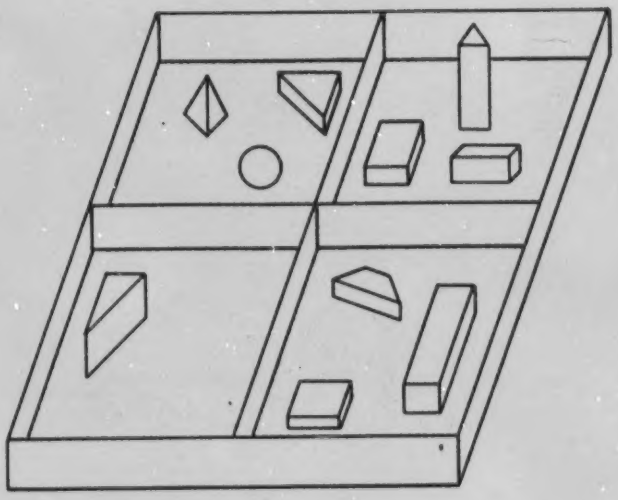
Use the distributive property to name the products.

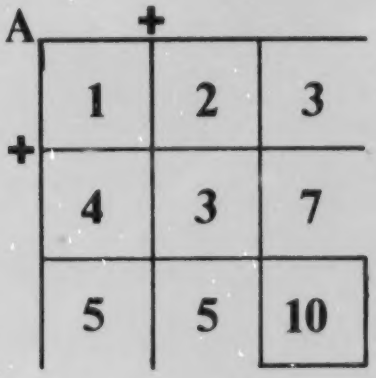
15. $\begin{array}{r} 48 \\ \times\ 6 \end{array}$
16. $\begin{array}{r} 59 \\ \times\ 4 \end{array}$
17. $\begin{array}{r} 105 \\ \times\ 3 \end{array}$
18. $\begin{array}{r} 131^{*} \\ \times\ 5 \end{array}$
19. $\begin{array}{r} 283 \\ \times\ 2 \end{array}$

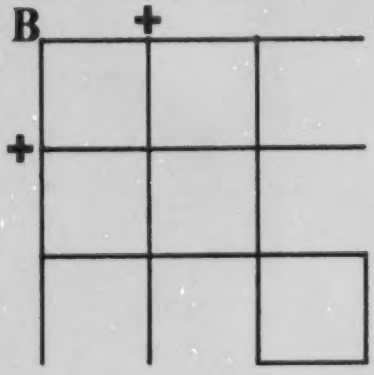
8. Calif. State Series. *Modern School Mathematics, 4.* Sacramento, 1970.

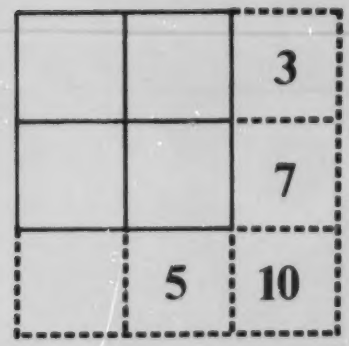
SAMPLE IX[9]
Level of ability_____
Number in sequence_____

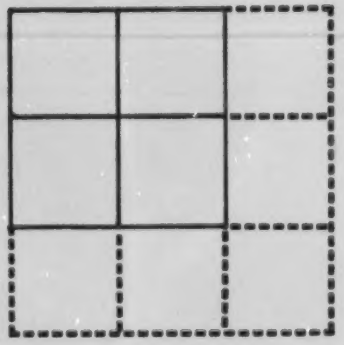










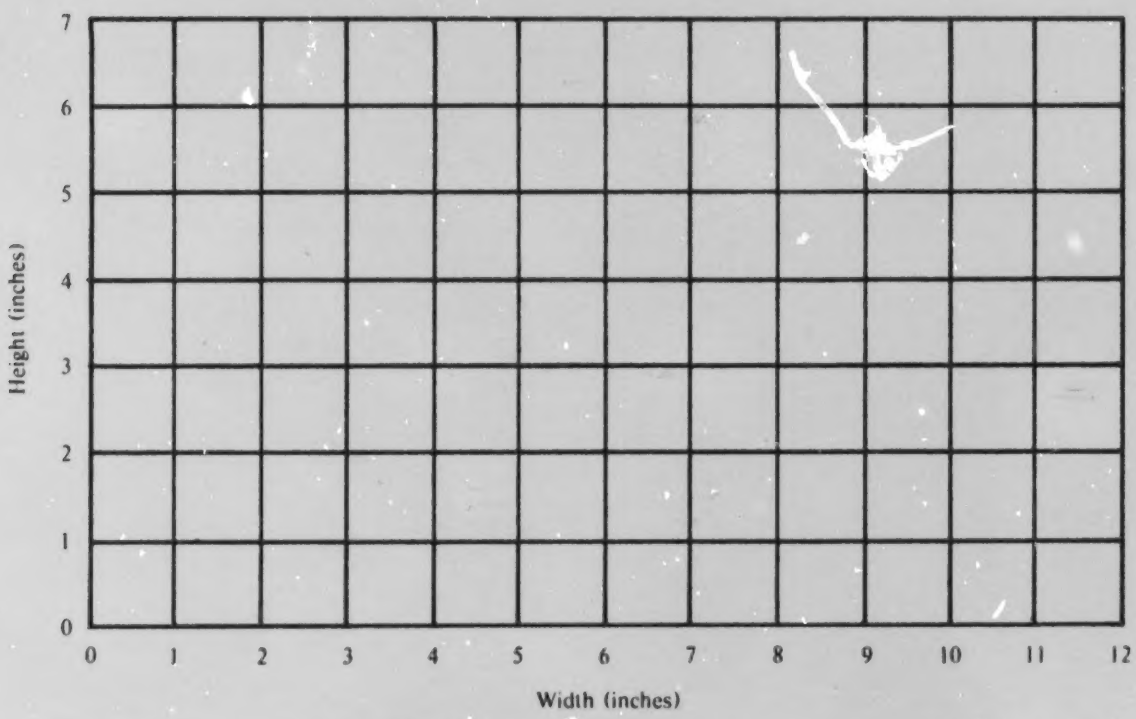


9 Wirtz, op. cit.

SAMPLE X[10]
Level of Ability_____
Number in sequence_____

Bill's older brother was learning how to work with a photographic enlarger at school. Bill had some snapshots of his dog that were three inches wide and two inches high. He wanted them enlarged to fit into some picture frames he had found in the attic. His brother said that in enlarging the pictures the shapes of the pictures would stay the same. If he made a picture twice as wide, it would be twice as high, and so on.

a. Make a graph to show how high the enlargement would be for different widths.



b. If Bill wanted one of his pictures to be five inches high, how wide would it be?
c. If Bill wanted another picture to be 10½ inches wide, how high would it be?

10. Elementary School Science Project. *Coordinates, Part IV.* Univ. of Calif., Berkeley, 1964.

Analysis of Mathematics Tasks

SAMPLE I: This task, for successful completion, requires the student to at least be at the Resemblance Sorting level of cognitive development. In this sample, identical sets are matched on a one-to-one basis.

SAMPLE II: This is an Inclusive Classifying task. Students must recognize coins of different values and combine the values to attain a total.

SAMPLE III: This Consistent and Exhaustive Sorting level task asks students to identify *all* sets *consistently* using the concept of six.

SAMPLE IV: This task involves the intersections of two sets and subsets, and thus requires Multiple Membership and Inclusive Classifying levels to do the task with understanding.

SAMPLE V: This task requires matching on a one-to-one basis. This is a Resemblance Sorting task.

SAMPLE VI: This task involves subsets or sets within sets as well as intersections of sets. The highest level of ability needed to do this task successfully is the Inclusive Classifying level.

SAMPLE VII: This is a Resemblance Sorting task similar to Sample I, but slightly more difficult in that the objects are not in the identical order in each of the sets to be matched.

SAMPLE VIII: This is a Horizontal Reclassifying task because it requires students to distribute and redistribute factors within an equation.

SAMPLE IX: This Multiple Membership Classifying level task asks students to work addition problems in two directions, then sum their totals at an intersection.

SAMPLE X: Graphing requires students to work with two variables at once to locate or interpret points in a two-dimensional space. This type of graphing requires that students be at the Multiple Membership Classifying level to understand the information.

The following indicates a numerical sequence for the above tasks according to levels of development.

1. Sample V
2. Sample I
3. Sample VII
4. Sample III
5. Sample IV
6. Sample IX
7. Sample X
8. Sample II
9. Sample VI
10. Sample VIII

WORKSHOP **J**

introducing the horizontal instruction model:

resemblance sorting level

The purpose of this workshop is to: 1) introduce the idea of "horizontal instruction" (instruction designed to match a particular level of cognitive development); 2) provide a variety of horizontal instructional examples for the resemblance sorting level of development; 3) allow practice in creating other horizontal instructional experiences appropriate for this level.

Most teachers are familiar with and trained in vertical sequencing of content—skills and concepts must constantly increase in complexity as students move through the grades, and the curriculum expectations for a student's performance must be constructed upon the indices of school grade, chronological age, or achievement scores rather than upon individual cognitive and affective development indices.

In the competitive social context of schools, American teachers inevitably ask about accelerating the stages of development through school intervention (Furth 1977). Administrative models of most American schools are congruous with and perpetuate the notion of a constant acceleration of stages in an ever-ascending vertical sequence.

In the current system, many students progressively lose control over their own rate and sense of success (Collins 1974, Covington 1976). The reasons for this are highly complex, but two aspects seem to be contributive: the potential for success diminishes in relation to the degree of mismatch between content and cognitive stage; as personal evaluation becomes official evaluation in formal schooling, the mistakes and errors that are a natural part of the learning process become misinterpreted as failures, and students become motivated to work for extrinsic symbolic rewards, such as gold stars and grades or to please adults, rather than for the sake of learning itself.

When cognitively mismatched content is accompanied by external expectations and rewards, the standards for successful performance are extended beyond the reach of many students. As Furth put it, intellectual health does not imply a "constant functioning at a high level — an entirely inhuman conception which is, however, not unlike the implicit demand of cumulative learning theories to do always better and better and to consider any downward movement as failure." Preliminary data collected since 1970 as part of the program that developed this *Learning about...Series*, suggests that the current accelerated vertical curriculum contributes to developmental disfunction — a slowing down or solidifying of stages plus asynchrony (very good performance in some things and very poor in others).

Through research conducted in some 300 classrooms, an alternative model to the vertical curriculum (but one compatible with the research presented in this book) has evolved. The model is termed the *horizontal curriculum.* It is one in which the student is challenged to use a particular mental operation with many different materials at various levels of abstraction without the progressive requirement of having to be at a more and more advanced stage of development. In operation the idea allows students at an identified level of development to explore many experiences within and near that level. Numerous researchers have contributed to the validation of this model in the sciences (Askham 1973; Loggins 1972; Lowery and Allen 1969, 1970, 1978; Mahoney 1970; Takahara and Choy 1975) and in mathematics (Collis 1971, Flavell 1963, Ginsburg 1977, Kennedy 1977, Langbort 1981, and Rupley 1981).

Through the horizontal curriculum, students experience small sequential steps of equilibration through an inexhaustible set of experiences which a teacher can develop with ordinary classroom materials. The essence of the material selection arises from Piagetian theory itself — the ability to operate at a level is generally independent of the objects involved in a given task. In the hands of a competent teacher, sorting activities might be designed to challenge a student who is at or beyond the *resemblance sorting* level of cognitive development as follows: (1) the student can be asked to find from an array of marbles two marbles that are alike on the basis of color, (2) the activity can be repeated using the same marbles but choosing another color as a focus, (3) the activity can be done with other objects using the same color or other colors, or (4) other physical properties. In each variation, the mental operation required remains the same — the pairing of two objects on the basis of a single property. Preliminary data indicate that the mental operation transfers easily to continually fresh situations and becomes more useable to the individual.

The horizontal curriculum can also extend students toward abstractions without requiring subsequently higher levels of cognitive development.

For example, if a student who is at or beyond the *consistant and exhaustive sorting* level can group all objects (e.g. leaves) within a set so that they logically belong together, the action is first-hand or concrete. It involves manipulations of real objects and not abstractions of reality (a). The student who can do the logical concrete action has the potential to impose the same mental operation on pictorial representations of reality without having to be at a more cognitively advanced level. Pictorial representations are one step removed from reality (b). Again, without having to be at a more advanced level, the same student has the potential to successfully carry out the same mental operation on symbols and abstractions which are several steps away from reality (c).

Development of horizontal curriculum experiences may provide significant cognitive and affective benefits by allowing students to operate upon progressively challenging tasks that are within a realm of potential success, while the accelerated and often mismatched vertical schemes may be inviting failure and erroding self-worth. Such a model for instruction allows teachers to be *teachers* having purpose for and power over materials rather than *administrators* who keep track of places and pages so that the sequence dictated by the materials is not interrupted.

	Concrete Experiences Seeing, Hearing, Feeling, Smelling, Tasting	**Pictorial Experiences**	**Symbolic Experiences**
Resemblance Sorting	← Horizontal Instructional Experiences →		
Consistent and Exhaustive Sorting			
Multiple Membership Classifying			
Inclusive Classifying			
Horizontal Reclassifying			
Hierarchical Reclassifying			

On the following pages are sets of possible resemblance sorting experiences that can be used as models to develop horizontal curriculum ideas in the area of beginning reading. Similar sets could be developed for other subject areas.

INSTRUCTIONAL ACTIVITIES APPROPRIATE FOR THE RESEMBLANCE SORTING LEVEL OF DEVELOPMENT

Concrete Experiences

Instruction that involves students in firsthand, perceptual experiences can span all the senses: seeing, hearing, feeling, smelling, tasting. The experiences can be structured in several ways: by presenting a clue and asking the student to find a matching object; by providing an array or reservoir of different objects among which two are identical and asking the student to find the two that are alike; by selecting objects that have very fine discriminating properties; by arranging objects so that their spatial orientations vary.

The Tasks

Seeing. The visual properties of objects that can be selected and arranged in instructional situations are: size, shape, color, and pattern. Although students might begin with grossly different objects, fine discriminations can be later used to sharpen perceptual awareness. Fine discriminations might involve closely matching lengths of sticks, serrations or venations of leaves, complex designs, shades or tones of colors.

1. String beads (identical in size and color but different in shape) on a string. Every time you string a bead, have a student string a matching bead. Subsequent stringings might keep the color and shape constant and vary the size or keep the size and shape constant and vary the color.

2. Buttons, coins, or other small objects can be glued to heavy cardboard. Ask students to find the two objects that are alike (Figure 1). Finer discriminations among the objects can be developed by selecting ones that are more closely alike (Figure 2).

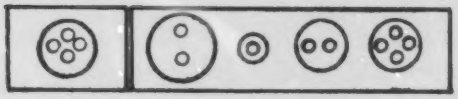


Figure 1

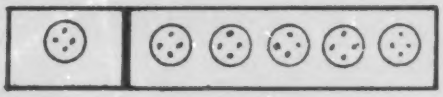


Figure 2

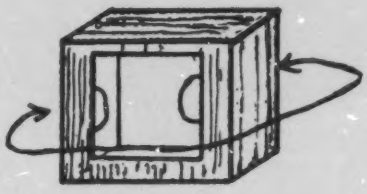
Hearing. Auditory properties that can be matched on a one-to-one basis are: pitch, intensity, and rhythm.

1. Have students listen as you play a single note on a musical instrument. Ask them to identify a matching note from a number of notes played in a series.

2. Using a pencil, tap simple rhythms on a desk. After students listen to the rhythms with their eyes closed, have them use pencils to repeat the rhythm that you tapped.

Feeling. Tactile properties have the greatest range of instructional possibilities. Materials can be selected to emphasize such aspects as size, shape, or textures (e.g., roughness, stickiness, softness, sharpness, etc.).

1. Prepare about eight squares of sandpaper, identical in size, but different in grade (roughness). Place the squares in a "feely box." Give students another square that matches, on the basis of roughness, one of those in the box. Ask the students to find the matching square. For finer discriminations, you might try using different grades of emery paper.



2. Place about eight wooden dowels of equal length but of different diameters within a "feely box." Be sure that two dowels have identical diameters. Have students use their sense of touch to locate the two that feel the most alike.

Smelling. Our sense of smell is not as acute as that of many other animals, and our vocabulary is limited. We generally describe smells by naming the object that gives off the smell (e.g., "It smells like a skunk." "It has a mint smell.").

1. Place six to eight bars of scented soaps into different containers. The bars should be identical in size, shape, and wrapped so that they cannot be distinguished on the basis of color. Place one more bar in another container and ask students to find, by smelling, the matching container within the set.

2. Wrap differently scented candles that are identical in size and shape. Place six to eight of them into boxes or cans. Add one additional box containing a candle that matches one of the others on the basis of its smell. Mix the boxes and ask students to find the two that smell alike.

Tasting. Generally our sense of taste is combined with our sense of smell. Other than the basic tastes of sweet, sour, bitter, and salty, flavors become complex combinations interwoven with our sense of smell, touch, and attitudes.

1. Give each student his or her own set of four small cups containing salt water, sugar water, quinine water, and water with lemon juice in it. Hand each student a fifth cup containing a liquid that matches in flavor, one of those in the other four cups.

2. Blindfold students. Let them taste four or five different foods (e.g., slice of lemon, cherry, orange, lime, pineapple). Next, give each a candy that matches one of the previous flavors. Ask them to identify which of the previous flavors it matches.

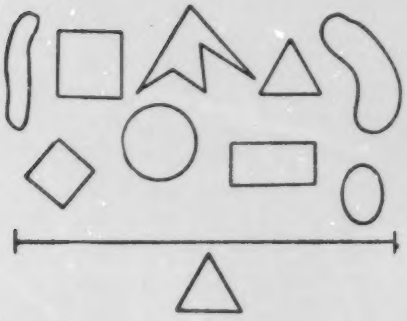
Pictorial Experiences

Instruction that does not involve students in firsthand (concrete) experiences but which represents the concrete by an illustration or photograph, is essentially an indirect experience. As with concrete experiences, pictorial experiences can be structured in several ways: by presenting a clue and asking the student to find a matching picture; by providing a reservoir of pictures among which two are identical and asking the student to find the two that are alike. Illustrations can also be drawn to involve students in making fine discriminations, or illustrations can be arranged to provide different spatial orientations.

The Tasks

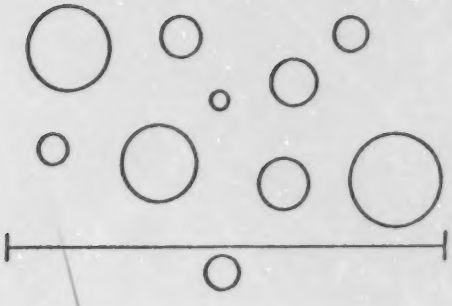
Only the visual properties described earlier (size, shape, color, pattern) can be utilized within pictorial experiences. These properties are a limitation of pictorial experiences. Each of the following examples asks students to find one picture that matches another picture.

1. Shape, Clue Given

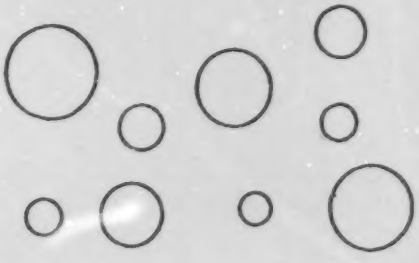


2. Shape, Clue Not Given

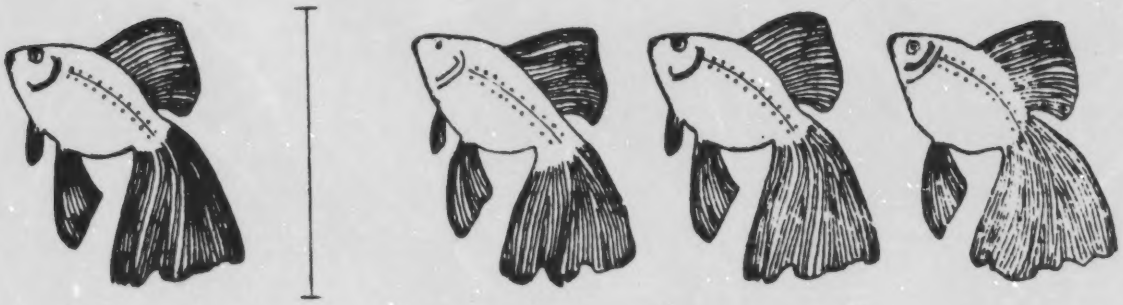
3. Size, Clue Given



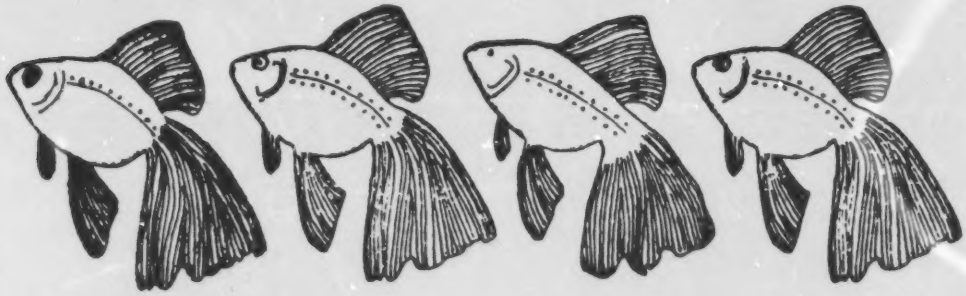
4. Size, Clue Not Given



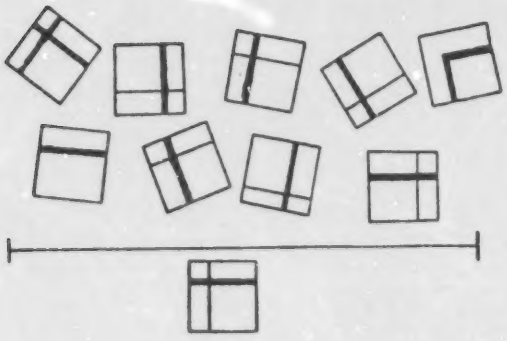
5. Fine Discrimination, Clue Given (from book)



6. Fine Discrimination, Clue Not Given



7. Orientation, Clue Given



8. Orientation, Clue Not Given

Symbolic Experiences

Abstract experiences are very indirect. Since symbols stand for something else, the experience is never firsthand, and it requires prior experience or knowledge to comprehend the experience. This is perhaps the greatest limitation to abstract experiences. It is possible, however, to mix abstract experiences with concrete or pictorial experiences.

All sensory properties described for concrete experiences can be conjured up through abstract experiences. For each of the following, students are asked to find the symbol (letter, word, or words) that matches another symbol.

1. Identical Single Letters, Clue Given

2. Identical Single Letters, Clue Not Given

3. Different Single Letters, Clue Given

4. Different Single Letters, Clue Not Given

5. Identical Configurations, Clue Given

6. Identical Configurations, Clue Not Given

7. Different Configurations, Clue Given

hat	**hop** *hit* **hut** *hat*

sit	*site* **sat** **sit** *set*

8. Different Configurations, Clue Not Given

run *ran* *sun* **ran**

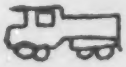
Bill **fill** *hill* *bill*

9. Semantics, Clue Not Given

		Same	**Different**
See me run.	See me run.	_____	_____
Look at them.	Look at these.	_____	_____
Open the door.	Open the floor.	_____	_____
Go right now.	Go right now.	_____	_____

10. Symbolic/Pictorial Combination, Picture Clue Given

Provide a reservoir of words, one of which matches a real or illustrated object. Ask the students to match each object with the word associated with it. NOTE: In this example, the student must distinguish among similar appearing words (fine discrimination).

Picture	**Words**		
	coop	**cop**	**cap**
	**track**	**truck**	**train**
	boat	**boot**	**beat**

11. Symbolic/Concrete Combination, Sound Clue Given

Make certain vowel sounds. Ask students to distinguish among a set of vowels, phonetically marked, and mark the vowel that matches each sound you make.

The samples presented in this Workshop were selected to give you a feeling for the almost limitless range of instructional possibilities for a particular level of development. Certainly many more can be created beyond what was presented here.

The samples were also selected to match one subject matter area — reading. Reading readiness and the sequential lead into actual reading have been emphasized because of their importance to the learner. Many of the ideas presented here are also useful for helping students in need of remedial work in reading.

WORKSHOP **K**

introducing the horizontal instruction model: multiple membership classifying level

The purpose of this workshop is to: 1) provide a variety of horizontal instructional examples for the multiple membership classifying level of development; 2) allow for practice in creating other horizontal instructional experiences appropriate for this level.

For each of the levels in the classification strand described in this book, it is possible to create a variety of "horizontal" (same level) experiences.

On the following pages are samples of concrete, pictorial, and symbolic activities for the multiple membership classifying level (each requires thinking about two or more ideas at the same time). At the end of each set of activities you are asked to create a similar activity on your own.

	Concrete Experiences Seeing, Hearing, Feeling, Smelling, Tasting	**Pictorial Experiences**	**Symbolic Experiences**
Resemblance Sorting			
Consistent and Exhaustive Sorting			
Multiple Membership Classifying	← Horizontal Instructional Experiences →		
Inclusive Classifying			
Horizontal Reclassifying			
Hierarchical Reclassifying			

Pictorial Experiences

Problems requiring the use of two or more properties simultaneously can be easily depicted in pictorial form. The basic form is shown in Figure 1. Variations are limitless (See Figures 2 and 3 and examples on subsequent pages).

The Tasks

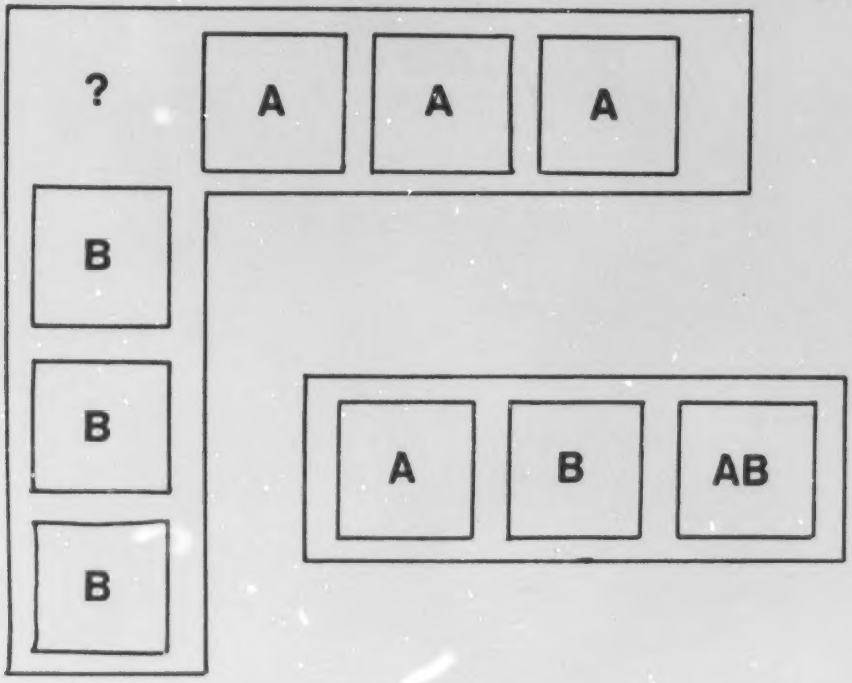


Figure 1: Basic Matrix and Choices

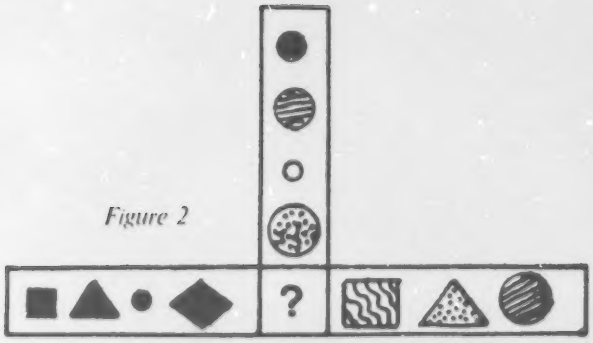


Figure 2

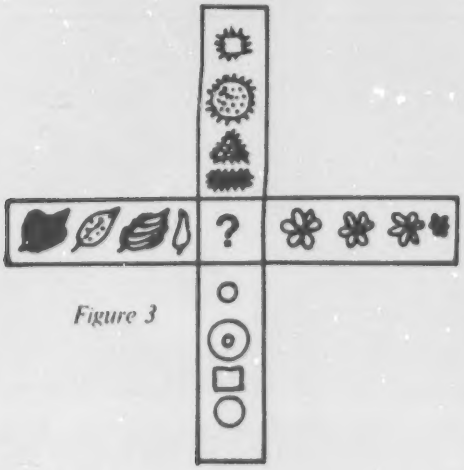


Figure 3

Pictorial Experiences

Problems requiring the use of two or more properties simultaneously can be easily depicted in pictorial form. The basic form is shown in Figure 1. Variations are limitless (See Figures 2 and 3 and examples on subsequent pages).

The Tasks

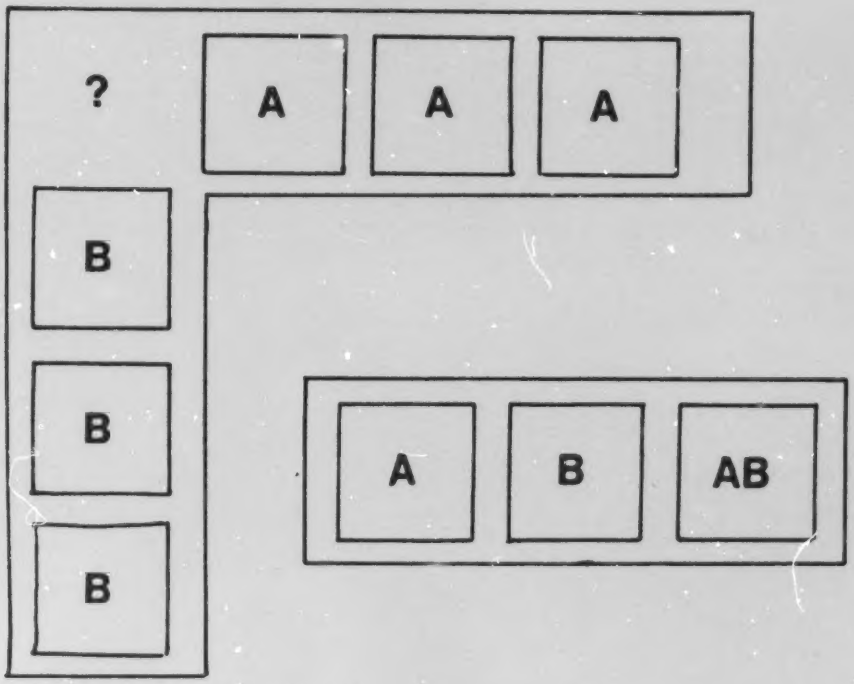


Figure 1: Basic Matrix and Choices

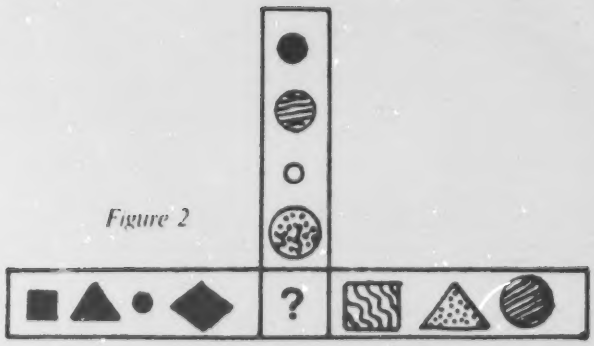


Figure 2

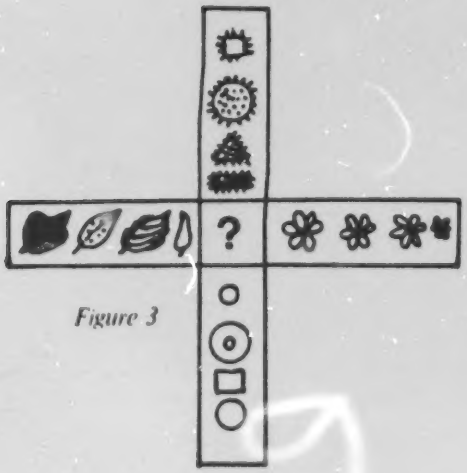


Figure 3

Which animal in C has the characteristics of the animals in A and B?

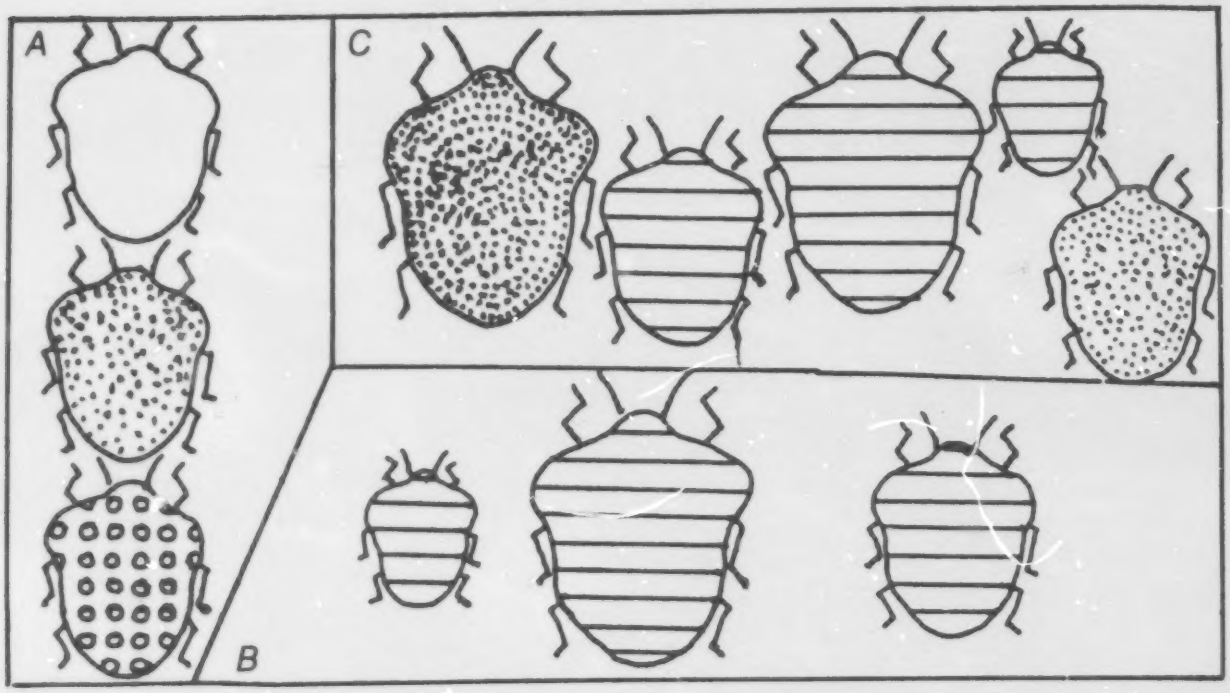


Figure 4

Which animal in C does not have the characteristics of A or B?

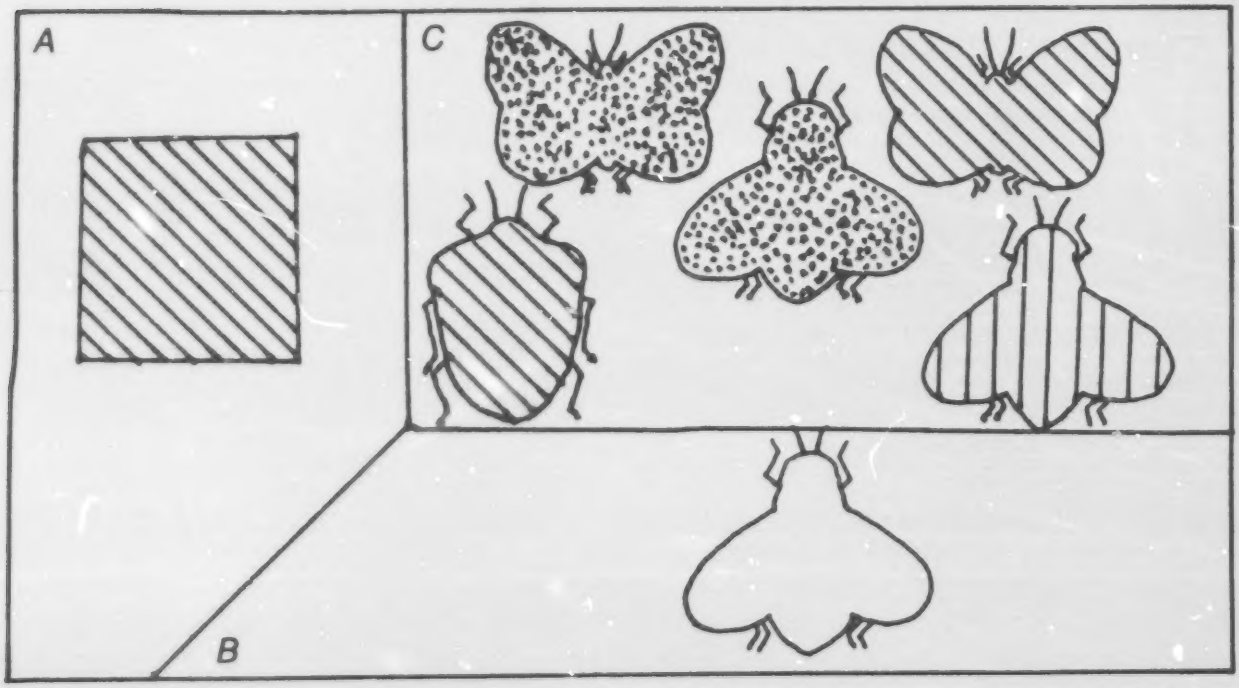


Figure 5

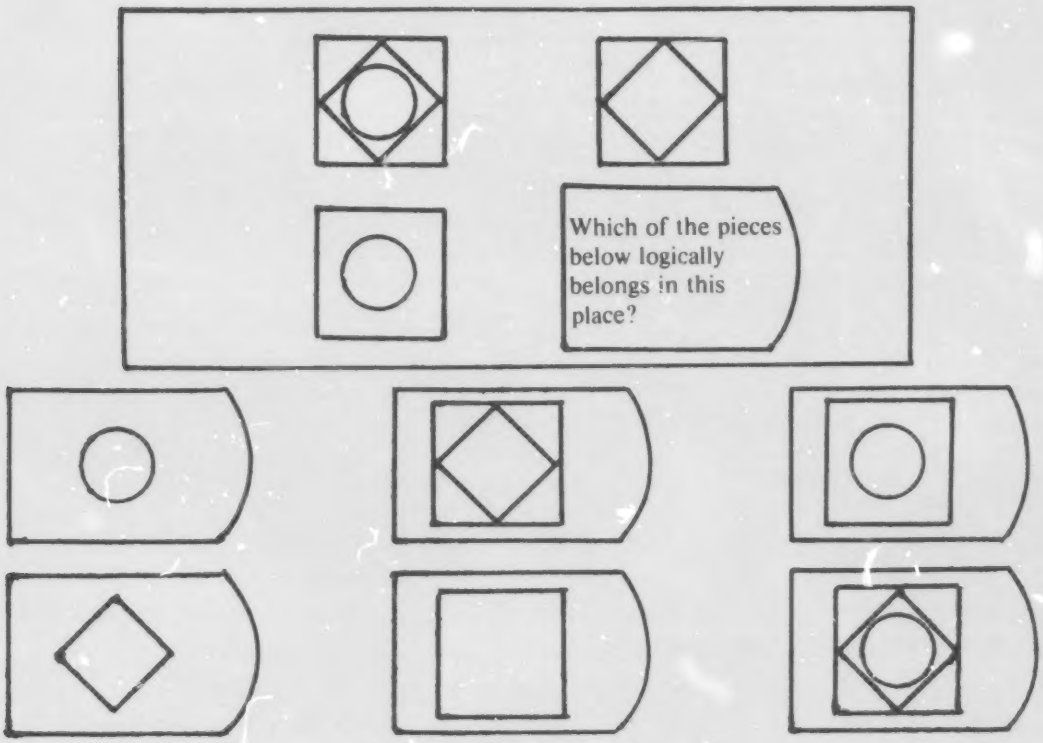


Figure 6

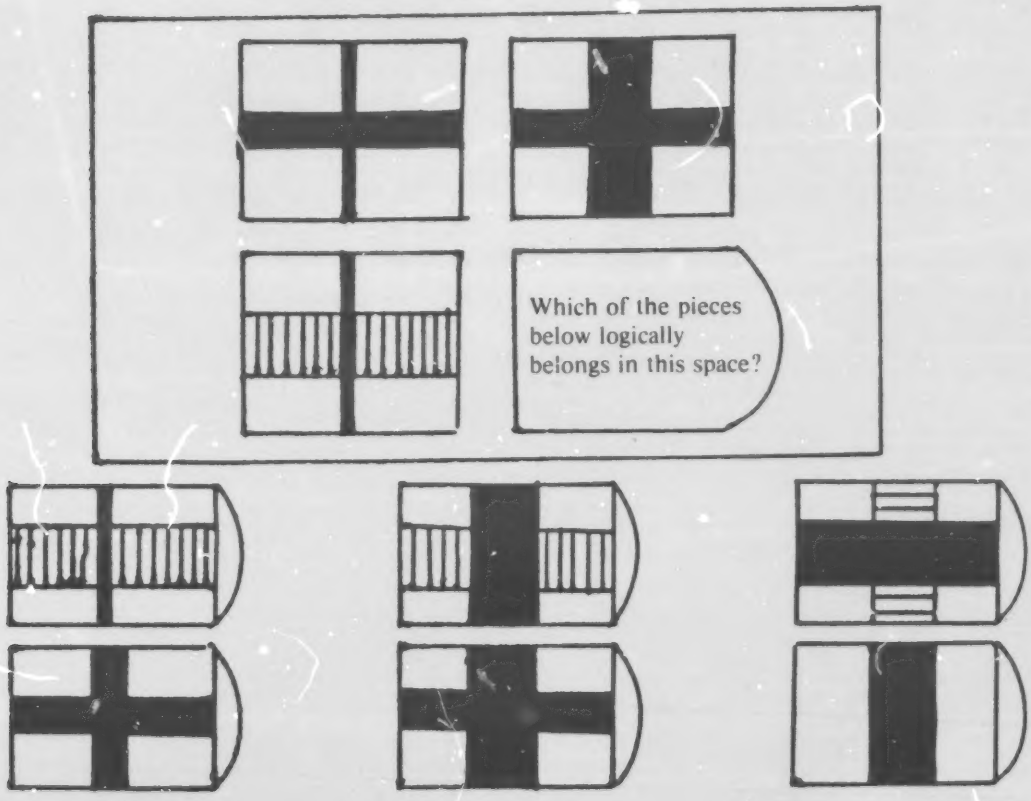
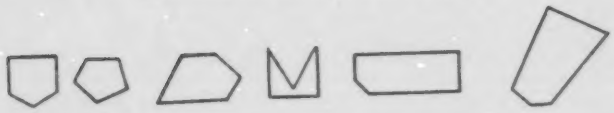
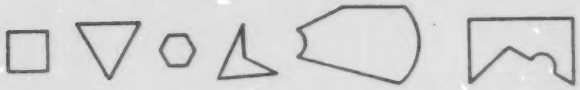


Figure 7

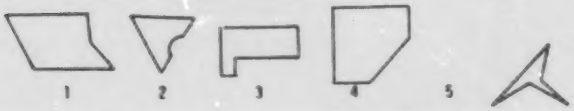
Each of these is a nogatnep:



None of these is a nogatnep:



Which of these are nogatneps?

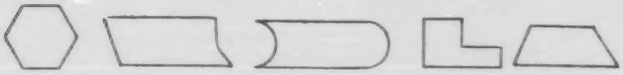


What is a mathematical name for a nogatnep?

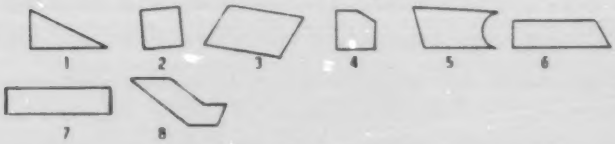
Figure 8

Each of these is a morgolellarap:

None of these is a margolellarap:



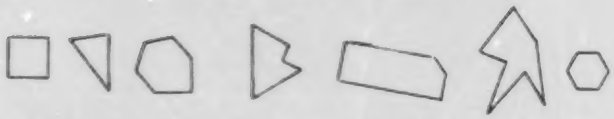
Which of these are margolelloraps?



What is a mathematical name for a margolellorap?

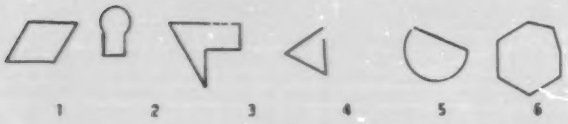
Figure 9

Each of these is a nogylop:



None of these is a nogylop:

Which of these are nogylops?



What is a mathematical name for a nogylop?

Figure 10

Now make up at least three pictorial tasks, each being modeled from a different form (e.g., one task similar to Figures 1, 2, and 3; one similar to Figures 6 and 7; and one similar to Figures 8, 9, and 10).

Symbolic Experiences

The diagram to the right shows:

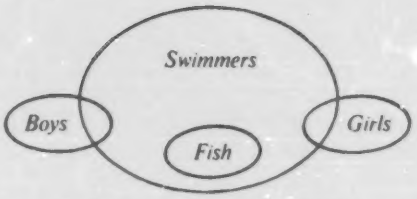
All fish swim.

Some girls swim.

Some boys swim.

Some girls do not swim.

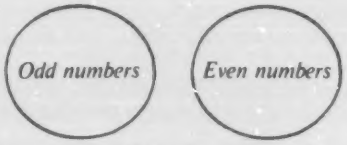
Some boys do not swim.



The Tasks

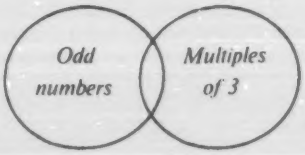
Study the diagrams. Write *T* or *F* to show whether each statement is *true* or *false*.

1. No even numbers are odd.
2. No odd numbers are even.
3. Some odd numbers are even.

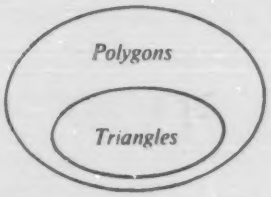


4. Some girls have blue eyes.
5. Some boys do not have blue eyes.
6. All girls have blue eyes.

7. Some multiples of 3 are odd numbers.
8. Some odd numbers are multiples of 3.
9. All odd numbers are multiples of 3.



10. If it is a triangle, then it is a polygon.
11. If it is a polygon, then it is a triangle.
12. If it is not a polygon, then it is not a triangle.



Now draw a diagram representing objects or concepts that have some but not all aspects in common. Make up a set of questions that ask students to think about relationships of the parts of your diagram.

WORKSHOP **L**

introducing the horizontal instruction model:

hierarchical reclassifying level

The purpose of this workshop is to: 1) provide a variety of horizontal instructional examples for the hierarchical reclassifying level of development; 2) allow for practice in creating other horizontal instructional experiences appropriate for this level.

On the following pages are samples of concrete, pictorial, and symbolic activities appropriate for students at the hierarchical reclassifying level of development. Students not at this level can enjoy doing the activities as well. However, their resolutions of the problems in each task will be limited by their levels of capability. One nice aspect about the tasks presented in this book is that each can be experienced at a variety of levels of development and students can feel successful within the extent of their capabilities.

At the end of each set of activities in this workshop, you are asked to create a similar activity.

	Concrete Experiences Seeing, Hearing, Feeling, Smelling, Tasting	**Pictorial Experiences**	**Symbolic Experiences**
Resemblance Sorting			
Consistent and Exhaustive Sorting			
Multiple Membership Classifying			
Inclusive Classifying			
Horizontal Reclassifying			
Hierarchical Reclassifying	← Horizontal Instructional Experiences →		

INSTRUCTIONAL ACTIVITIES APPROPRIATE FOR THE HIERARCHICAL CLASSIFYING LEVEL OF DEVELOPMENT

Concrete Experience

The Simulated Moon Mission

From a rock collectors shop, obtain a balanced amount of each of the following nine materials to fill a small vial for each group of four to five students. The nine materials are suggestions of what could be found in an explored region of the moon. Other materials could be used.

MOON MATERIALS

Object	Properties	Name
	black, flakes, fractures in one plane	biotite
	white, rhombic fracture	calcite
	gray, metallic cubic fracture	galena
	white, cubic fracture	halite
	white, glassy irregular fracture	milky quartz
	transparent, fractures in one plane	muscovite
	gray/black, glassy, irregular fracture	obsidian
	pink, fractures in two planes	orthoclase
	pale pink, glassy, irregular fracture	pink quartz

Obtain small vials with lids from a pharmacist—one vial for each group.

Distribute the materials and the following directions to each group.

Have a good moon trip!

Directions for Moon Trip

Place a sheet of white paper on a flat surface. This sheet represents a previously unexplored region of the moon. You will be given some objects in a container. These objects represent the materials that are found in this region. Spread the objects out on the paper.

The Task

Collect samples of as many different kinds of objects as you can find. Place samples in the small plastic vial provided for this purpose. All samples that you select as being representative of the region must fit into the vial because there is a limitation on the amount of material you can bring back to earth. The cap to the vial must fit properly for the return trip.

Keep a written record of your observations on the mission. Your notes might describe the objects selected and contain a brief discussion of any problems you encountered or unique features you found in the area explored.

You are limited to 15 minutes in which to carry out the task. Upon your return, prepare to present your findings to interested scientists.

Pictorial Experience

The Simulated Fossil Hunt

The imaginary organisms illustrated for the task that follows, were designed by J. H. Camin and used in a research study by R. R. Sokal ("Classification: Purposes, Principles, Progress, Prospects," *Science*, 1974, *185*, 1115-1123). The organisms represent "fossils" that might have been found in layers of sediments in the earth's crust. To do the task, students should assume that all pertinent information necessary for determination of evolutionary sequences (phylogenies) and taxonomic constructions is present in the drawings. Organizational problems have been simplified by omitting information concerning paleogeographic distribution of the organisms. The following task can be reproduced and distributed to students.

The Task

On the following pages are 66 illustrations of imaginary organisms. These organisms were derived from "fossil remains" discovered in layers of sediments. The organisms can be matched to specific Geological Time Periods as shown below:

Geologic Time Period	Years Ago (Beginning)	Organism Number
Triassic	190,000,000	66
Jurassic	155,000,000	64-65
Cretaceous	115,000,000	60-63
Paleocene	60,000,000	54-59
Eocene, Part 1	55,000,000	49-53
Eocene, Part 2	50,000,000	43-48
Oligocene	40,000,000	29-42
Miocene, Part 1	31,000,000	23-28
Miocene, Part 2	20,000,000	15-22
Pliocene	13,000,000	8-14
Pleistocene	2,000,000	4-7
Recent	25,000	1-3

1. Determine the sequence of evolution among the various organisms by cutting the illustrations apart and placing them in proper time intervals on a large sheet of paper. Connect ancestor-descendant relationships with light pencil lines and rearrange or alter them as necessary. Assume all younger organisms were derived from the one ancestral Triassic species.
2. On the chart below, summarize your evolutionary tree using only the number of the organism and connecting lines.
3. What can you say about the possible life habits of any of the organisms on the basis of their physical properties?

Evolutionary Sequence Chart

Triassic

Jurassic

Cretaceous

Paleocene

Eocene 1

Eocene 2

Oligocene

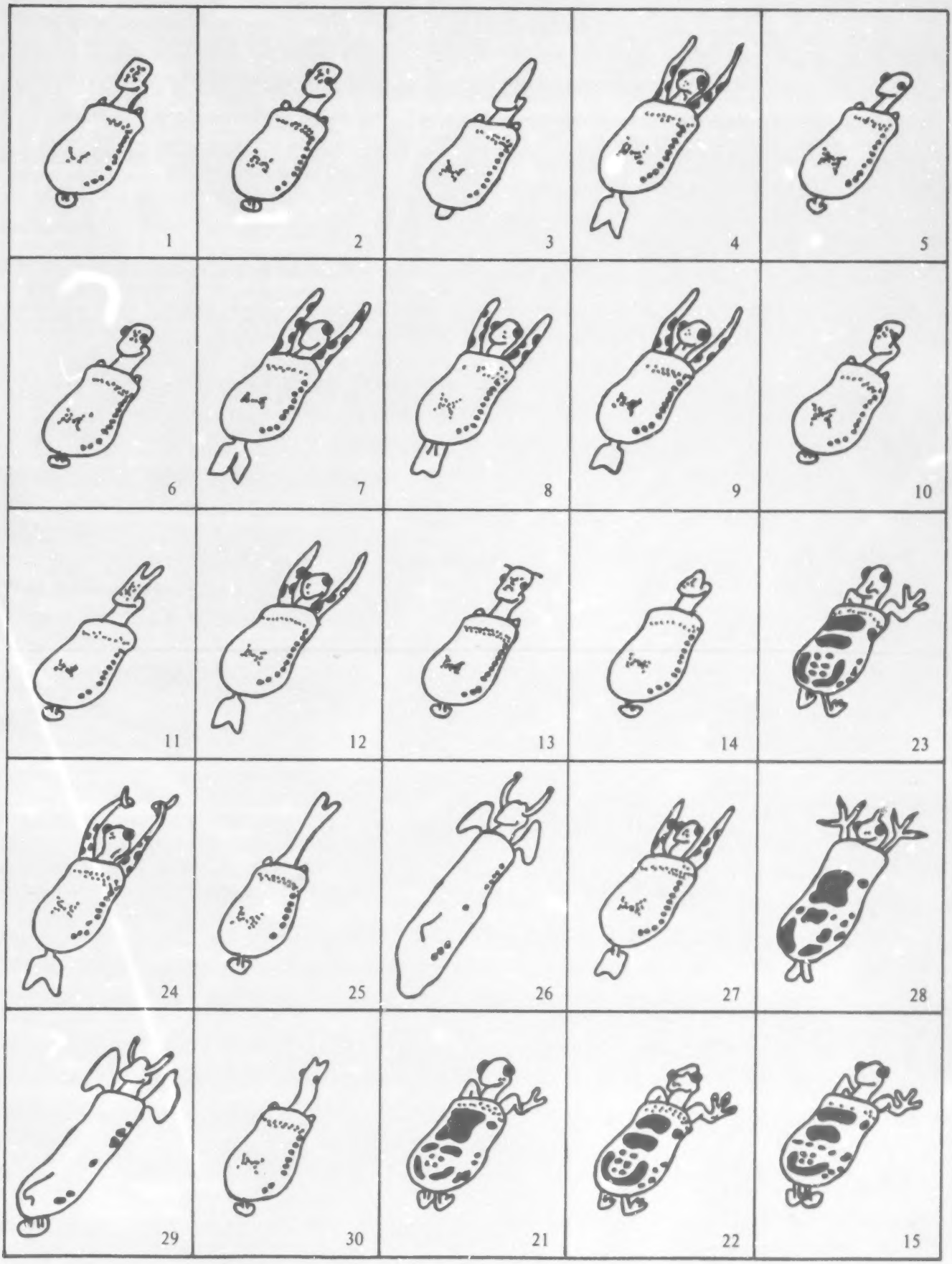
Miocene 1

Miocene 2

Pliocene

Pleistocene

Recent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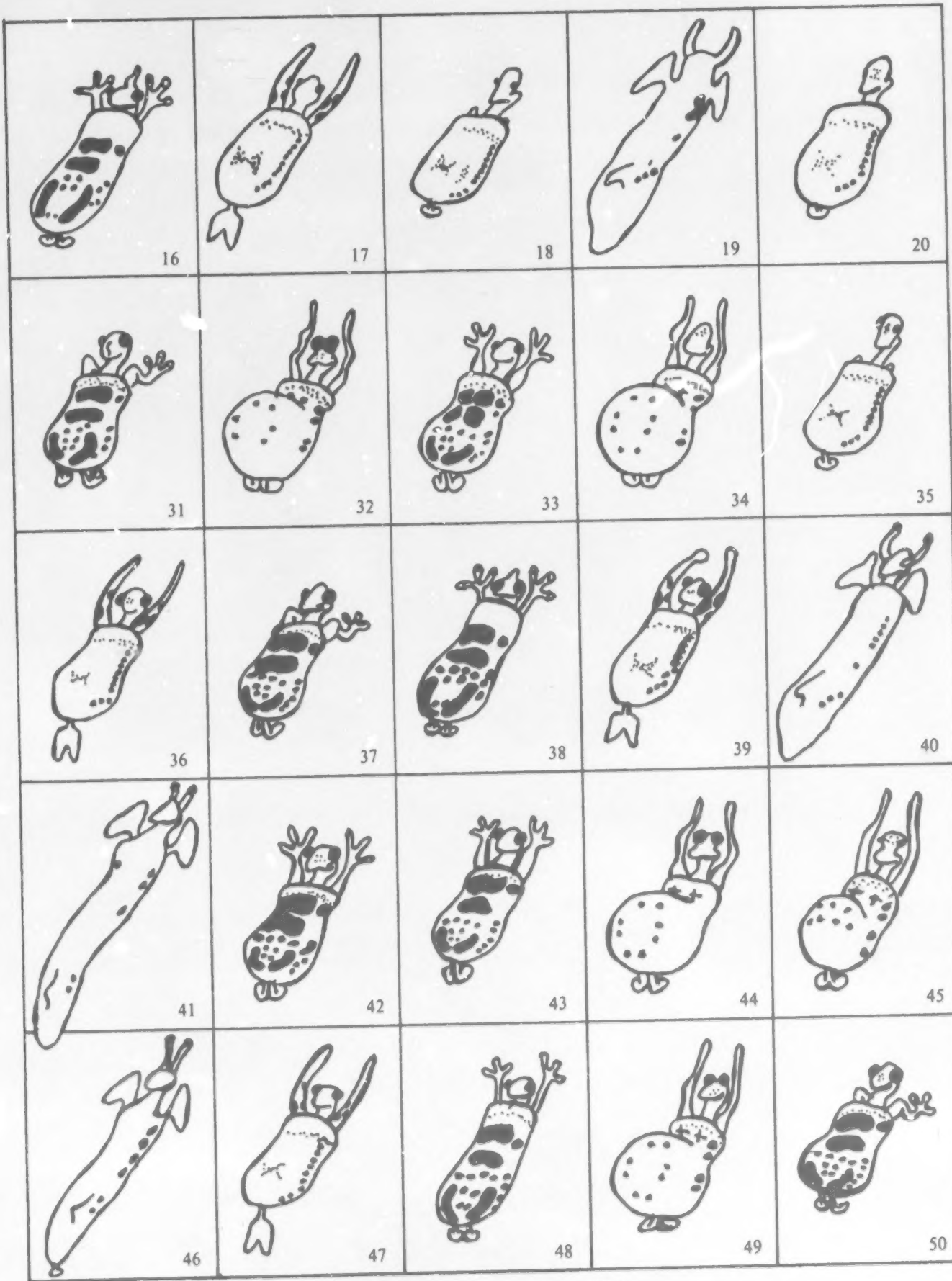
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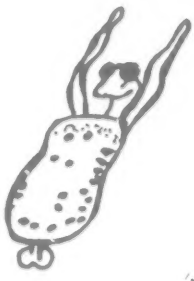

66

Symbolic (Abstract) Experience

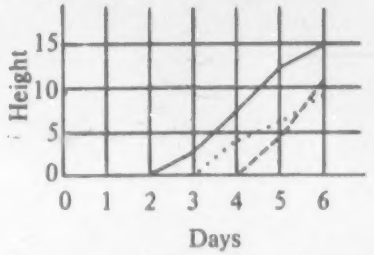
Diversity and Classification

Even though objects can be grouped together by similarities, there is always much diversity among the objects. All who read this page are classified by scientists as Homo sapiens in the biological classification scheme. But not all of the readers look alike. Some are tall, others short. Hair and eye coloring differ among individuals. Identical twins even have different fingerprints. No two objects in the world are exactly alike. The following classification task can be reproduced and distributed to students—or an actual "growing and gathering data" experience can be used to produce similar interpretive graphs.

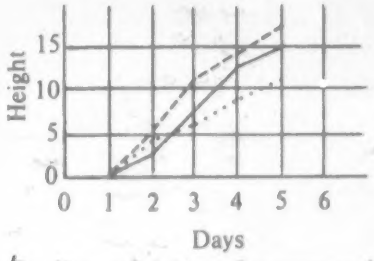
The Task

This task allows you to determine diversities among objects that are very much alike.

1. From a group of radish or bean seeds, choose 10 that look as much alike as possible. Be sure they are the same in shape and color. Measure them to be sure sizes are the same. In what other ways should they be alike?
2. Plant the 10 seeds and number their containers so that you can keep track of each seed. See that the soil, sunlight, temperature, lighting, and watering conditions are the same for each. Also be sure each seed is planted at the same depth and placed in the same position. What other aspects should you control?
3. Measure the height of each plant from the first day it appears. Record your measurements and observations in a notebook on a daily basis.
4. After a week, prepare two graphs.
   a. One graph should compare the number of days it took each plant to appear.
   b. A second graph should compare the growth rates of the plants. This can be accomplished as shown on the second sample graph.



a.



b. (From first day of appearance)

5. Answer or do the following:
   a. Based upon your notebook data, list the differences you noticed among the 10 seeds.
   b. What advantage or disadvantage do such differences have for the plant?
   c. How can the data you collected be used to reclassify the seeds?
6. Now create a concrete, pictorial, or symbolic activity modeled after one of the preceding examples. Although these examples are in the area of the natural sciences, you might try creating an activity in such areas as literature, music, or art.

REVIEW OF SOME RESEARCH ON CLASSIFICATION ABILITIES

Prolog

Classification abilities, together with interpretive abilities and associative thinking, are important aspects of the cognitive processes by which humans organize and connect together the input from their environment. Classification (or categorization, or grouping, or sorting) is of great importance in everyday thinking because it is a necessary preliminary to concept formation, the process by which we make sense of our environment through the realization of what things go together. This deliberate classification is of practical value for it limits the amount of information with which we need to concern ourselves.

Concepts are learned by sorting, in an appropriate fashion, the information that is received through our senses; thus concepts are simply classifications of stimuli that have one or more common characteristics or atttributes. Bruner, Goodnow, and Austin (1956) state that to classify "*is to render discriminably different things equivalent, to group the objects and events and people around us into classes, and to respond to them in terms of their class membership rather than their uniqueness.*" And McDonald (1965) states that once a repertoire of concepts is available, they "*serve as devices for sorting information, and this sorting process determines the way in which the person will organize new information into new concepts.*"

According to Wallace (1965), grouping skills are necessary not only for effective conceptualization, but are also necessary for "*reasoning, since so much of the verbal behavior often vaguely called 'abstract thinking' appears to consist of reasoning about classes and class membership. This includes mathematical reasoning since numbers are classes of classes.*"

Log

Interest in classification abilities began during World War I with a study of impairment of abstract behavior. It was discovered that the abstracting ability of brain-damaged patients differed markedly from that of normal individuals. Eventually, various sorting tasks were developed for diagnostic purposes (Halstead 1940). Subsequent to the analysis of performance changes in brain-damaged patients, these tests were used with normal individuals of all ages for the study of concept formation, particularly with children, where a striking parallel was found to exist between pathological and child thought.

In studies attempting to examine the nature of human thinking, Inhelder and Piaget (1964) came to describe three stages of conceptual development through which classification abilities are sequentially attained. In Stage I the child groups classifiable material into figural collections in which the collection "*looks like a train*" or "*looks like a face.*" In Stage II the figural collections give way to non-figural collections. The child now sorts or groups objects on the basis of similarity of single attributes (e.g., size, shape, or color). In Stage III the child can mentally handle two or more attributes simultaneously and can eventually keep in mind that a subclass is included in a superordinate class and that all classifications that are tentative thus can undergo limitless reclassifications.

Concept Formation Studies

Since the early studies, the major area of research using classification tasks has dealt with concept formation. Within this research, the majority of work has been limited to empirical determinations of classificatory performance of individuals at different ages. These studies of concept formation have been summarized by Vinacke (1952), Werner (1957), Wallace (1965), and Kofsky (1966).

A typical empirical study was carried out by Annett (1959). She used 303 children between five and 11 years of age and 42 adults between 18 and 73 years of age. Her sorting test consisted of 16 cards with uncolored line drawings, four of which depicted animals, four plants, four vehicles, and four articles of furniture. Each subject was instructed to "*Sort the cards into groups so that the ones that go together are in the same group.*"

The more than 200 combinations of cards which were produced illustrated well the problems of interpretation facing the experimenter dealing with classification tasks. Half the 200 combinations occurred only once. Examples of all types of sortings were found in all age groups. A complete four-by-four sorting into animal, plant, vehicle, and furniture groups was made by only 24 children and 11 adults, and only one child and one adult made a complete two-by-eight sorting into living and non-living things. Annett determined that:

a. The number of sorting combinations produced was reduced as age increased.

b. The content of the explanations given did not change with age.

c. The structure of the explanations or the ways the facts were used in relating object together, changed with age.

The explanations given by the subjects were found to be of five types: 1) no explanation, 2) enumeration (different facts given about each object in turn), 3) continuity (objects related together in a direct, concrete interaction based on place, time, animal, or human activity), 4) similarities (a characteristic common to the objects is given), and 5) class names. The adults generally (although not always) gave explanations acceptable for correct, logical thinking, but the older adults performed more like children in that they gave more enumerations and contiguities. The order of development of the five types of explanations remained the same whether the data were analyzed for age or for intelligence.

Concept formation apparently involves learning how to discover and select attributes, that is, classificatory criteria, appropriate to the matter at hand and "*learning to deal with relationships among these attributes*" (Elementary Science Study 1966). Whiteman (1962) believes that concept formation must mean sensitivity to the common features forming a class. The criteria for classification must be carefully chosen by the individual himself for the particular situation so that the resulting concepts are of maximum value to him and lead to effective thinking.

Evidence which indicates that the ability to form class concepts is the most fundamental cognitive process can be summarized as follows:

1. The attainment of class concepts is relatively independent of verbal props. For example, grouping is recognized in the behavior of children as young as 1½ years (Stott 1961) and in non-verbalizing organisms lower on the phylogenetic scale such as Macaque monkeys (Andrew and Harlow 1942). Wallace (1965), however, points out that only elementary levels of classification, that is grouping of objects on the basis of shape and color, can be entirely independent of language, and that the more advanced classificatory operations cannot be attained without a verbal basis. Again, a study by Oleron (1956) showed that deaf-mute children between five and eight years of age were as successful as normal children in classifying by color, shape, and size, but experienced great difficulty in classifying at a more abstract level.

2. Lovell (1955), using a battery of classification tests, reported strong evidence that the ability to categorize was not adequately measured by conventional factors.
3. Class concepts, at least the elementary ones, remain virtually unaffected by variations in the cultural and socio-economic environment (Goodenough 1962; Price-Williams 1962).

Visual Classification Studies

It is quite clear that the visual aspects of objects play an important role in how the objects are sorted or classified.

Lowery and Allen (1969, 1970, 1973) found that for first graders, shape is visually an easier attribute to handle than pattern, and pattern is easier than size. In addition, they found that it was much easier for the child to use a single attribute rather than two attributes simultaneously and that two attributes could be handled more readily than three. Most importantly, they found that situations in which positionings or fine discriminations were used as ordering attributes required abilities which the children did not yet possess. It may be that these abilities are never acquired for certain objects or stimuli, particularly those that are not part of one's everyday environment.

Askham (1972) found that nine- to 12-year-old students classified plants growing in a semi-natural outdoor environment differently than they classified objects in a classroom setting. Moreover, the degree of classificatory stimulation engendered by specific plants was dependent upon their distinctive characteristics and their physical proximity to the student. The setting and/or the naturalness of objects may influence the ways in which the objects are classified.

Shifting of visual attributes may be an important facet of the classification process. Schell (1971) found that students attend to one attribute at a time when stimuli vary in several attributes, but that when required to, they learn to shift quickly from attribute to attribute. Bryant (1966) found that children below the age of six shifted between dimensions (e.g., color to shape) more easily than they could shift between stimuli within a dimension (e.g., blue color to green color).

A study with deaf children indicated that shifting within a dimension is easier for older students and adults and is easier than shifting from one stimulus dimension to another (Youniss 1964).

Most studies of visual classification abilities have demonstrated that broad conceptual abilities appear at given age levels, or in some sequential order, or in association with cultural or pathological characteristics. Gardner (1953), A. E. Goldman and M. Levine (1963), E. Hanfmann and J. Kasanin (1937), Price-Williams (1962), and many others have sought to reveal patterns of development related to broad categories of age, experience, training, and sex, but all have also neglected to document what Lowery and Allen define as horizontal fine structures — the degrees of difficulty within a level of ability. To Lowery and Allen (1973), horizontal fine structures may consist of task-oriented variables such as shape, color, pattern, function, and value, or they may focus upon the learner in which case, age, sex, and socio-economic status become the relevant dimensions.

Loggins (1974) explored horizontal fine structures by seeing if there were performance differences, due to socio-economic status and sex, age, and task variables, among seven- and eight-year-old children on visual multiple membership classifying tasks. He found that upper and middle socio-economic status (SES) students performed better than lower socio-economic status students; lower SES boys outperformed lower SES girls; upper and middle SES girls outperformed boys; all students did better on tasks involving differences than on tasks involving similarities.

Socio-Economic Status Studies

In a study of lower and middle-class children, it was found that classificatory success was dependent, in part, on the mode of presentation; failure increased when the children were presented with colored pictures of objects to be grouped rather than the objects themselves (Sigel, Anderson, and Shapiro 1966). It was concluded that lower-class children had not yet acquired adequate mental representations of familiar objects. Yet both groups of subjects verbalized their responses equally well. It was found that there was no significant difference in verbal responsiveness as a function of I.Q.

In a study done with kindergarten children of high and low socio-economic status, Johnson (1968) found that both could consistently categorize on the basis of attribute resemblance, especially when the attribute of shape was involved. The mastery of categorization, Johnson concludes, is both necessary and natural and begins with birth and not with entrance into school.

Working with underprivileged children in Israel, Sharan and Weller (1971) found that girls emerged superior to boys on all measures and lower-class children generally employed color as a determinant for grouping more than did middle-class children. In the United States, Lowery and Allen (1970) found that upper socio-economic status first grade girls performed better than boys on tasks pertaining to single and double variables of shape, pattern, and size. Both studies found that lower-class children were less able to achieve the required conceptual depth when compared with their middle-class peers.

Cultural Studies

Research that examines the cultural universality of classificatory development is fairly extensive. Wei, Lavatelli, and Jones (1971) reported that the culturally different groups in their study progressed through the same developmental sequence but at a slower rate. No sex differences were found.

The data available on color and size studies transcend cultural boundaries. Schmidt and Nzimande (1970) found "*overwhelming incidence of color preference*" in their study of Zulu children and illiterate farm workers. The results were remarkably similar to those obtained by Suchman (1966) in his study of Hausa (African) children attending traditional (not Western-type) schools. Bruner et al (1956) report that Greenfield, Reich, and Oliver, using different types of tests, came to similar conclusions about unschooled Wolof Bush children. In effect, they found that the use of color as a grouping attribute increased with age and that the use of form and functional attributes was virtually non-existent at any age. In addition, the Wolof illiterate adults demonstrated the same reliance on color attributes as the Zulu farm workers.

Color again appears to be the dominant determinant in forming classification schemes in Price-Williams (1962) study of Tiv (African) children. In his study, however, he disregards this attribute and concentrates his attention on the concrete attributes of "*legs*," "*domesticity*," and *edibility* in animals and "*roots*," "*two-leafed*," and "*from the earth*" in plants. From this study it appears that primitive children, even when exposed to Western-type education, classify objects on the basis of the object's relationship to their livelihood. Price-Williams also found that Tiv children express a growth in the capacity to reach the state of concrete operations when they have had an opportunity to manipulate familiar materials. Furthermore, this growth proceeds at a similar rate in both schooled and illiterate children and compares favorably with European children. In effect, these results add credence to the work done by Piaget and his associates in Geneva.

Studies by Lovell, Mitchell, and Everett (1962) repeated Piaget's experiments in other

countries and confirmed the classificatory levels of conceptual development. Although differences occurred with different cultural backgrounds, the order of levels remained constant.

Lowery and Allen replicated their earlier work on horizontal fine structures at the visual resemblance sorting level with Malaysian first grade students (1978). They found no significant differences between the Malaysian children and U.S. children.

Epilogue

If a child below the age of seven is asked to respond to a series of questions or tasks about motion, number, birth, death, and so on, his or her answer would be incorrect as judged from an adult point of view. More than half a century ago, Piaget realized that an analysis of incorrect answers could help in understanding the way in which children's conceptions of the world are organized. From his observations he noted two facts about responses: (1) within a two- to three-year range, children tended to give the same kinds of incorrect answers; and (2) as children grew up, there seemed to be a sequence of change in which one view of the world was replaced by a more sophisticated view which in turn was replaced by a still more sophisticated view. In attempting to explain the similarities and trends in conceptions, Piaget developed a framework indicating the developmental sequence. Classification research provides strong evidence for a developmental nature to the process, and much of this evidence is compatible with Piaget's sequence. Although some discrepancies exist on specific factors, Lowery (1972) found it possible to sort from the literature the agreements from the disagreements, thus identifying a strand of classificatory levels within the Piagetian framework. (See next page.) The sequence is composed of seven levels within four stages of classification ability. Cowan (1978) summarized the array of replicated studies done in various locations and stated, "All of these studies support Piaget's general statements about progression and sequence."

PIAGET'S DEVELOPMENTAL SEQUENCE | **LOWERY'S STRAND**

Periods of Development	Ages*	Classification Abilities
I. Sensory-motor Period (birth to about 2 years).	0	
II. Concrete Intelligence Period (about 2-11 years).	2	Accidental Representation (1-3).
a. Preconceptual Stage (2-4 years).	4	Resemblance Sorting (3-6).
b. Intuitive Thinking Stage (4-7 years).	6	Consistent/Exhaustive Sorting (6-8).
c. Concrete Operations Stage (7-11 years).	8	Multiple Membership Classifying (8-10).
III. Formal Operations Period (about 11-18 years).	10	Inclusive Classifying (10-12).
	12	Horizontal Reclassifying (12-14).
	14	Hierarchical Reclassifying (14+).
	16	
	18	

* All ages listed on this page are approximations.

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appendix

Record of Classification Tasks

Student_____ **Age**_____

Administered by_____

Task	Student's Responses	B	T	A	Administrator's Comments	Date
Resemblance Sorting						
Consistent & Exhaustive Sorting						
Multiple Membership Classifying						
Inclusive Classifying						
Horizontal Reclassifying						
Hierarchical Reclassifying						

NOTE: B = Below Level
T = Transition
A = At or Above Level

Record of Classification Tasks

Student_____ **Age**_____

Administered by_____

Task	Student's Responses	B	T	A	Administrator's Comments	Date
Resemblance Sorting						
Consistent & Exhaustive Sorting						
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NOTE: B = Below Level
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